THE UNIVERSITY OF
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THE DEVELOPMENT AND IMPLEMENTATION OF A COLLABORATIVE ARCHITECTURE FOR SMES

EXECUTIVE SUMMARY

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Abstract

Small manufacturing based businesses compete in an increasingly competitive global market, a market which is under pressure to deliver more complex and advanced engineering solutions and more complete services to their customers. In the automotive sector for example, a trend is the change from the purchase of individual components and products to the outsourcing and supply of complete engineered systems. In order to compete and grow their capability SMEs (Small to Medium sized Enterprises) need to find and collaborate closely with complementary partners in order to acquire new skills, technology, resources, tacit knowledge and know-how.

To address these difficulties the author developed, implemented and tested a Low Cost Virtual Teaming (LC VT) Collaborative Toolset and more importantly a Collaborative Architecture or business model specially for enabling e-business within manufacturing based SMEs. Both the Toolset and the Architecture are supported by a Collaborative Process methodology, containing rules and protocols.

The research methodology followed close interaction with many organisations working within the field, and the use of a number of research methods to gain balance and rigour. Additionally, feedback from the field resulted in improvements where required and kept the model up to date and relevant. A mixed methodology approach was taken to give a broader and complementary view of the issues to ensure balance within the research leading to a more comprehensive understanding of the issues.

The research presents an architecture that provides an industry independent e-marketplace to facilitate the communication and collaboration between the OEM and SME supplier groups to enable the pooling of information and knowledge. The Collaborative Architecture considers the whole cycle of the work processes from identifying and finding new suppliers and winning new orders, through to collaborative product development and to providing production order information.

Initial research projects, undertaken by the author, provide key research results, which helped secure secondary funding for a second phase project which was over £3.6m. The West Midlands Collaborative Commerce Marketplace (WMCCM) is an integrated e-business infrastructure project for enabling the West Midlands manufacturing SMEs (1,800 SME members) and facilitates finding new business, finding complementary partners, and also creating and supporting collaborative activities. WMCCM brings together the outputs of the research from the AutoLean III and Autocle@r projects through an integrated collaborative business model.

SMEs that can find new sources of work, form partnerships to pool their expertise to help undertake it, who have the know-how to form effective Virtual Teams and can access tools to support collaborative working, are more likely to succeed in the continuing competitive times which lie ahead. The Collaborative Architecture aids SMEs to meet this paradigm.

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List of Abbreviations

ADSL	Asymmetric Digital Subscriber Line
B2B	Business to Business e-business
CAD	Computer Aided Design
EDI	Electronic Data Interchange
EngD	Engineering Doctorate
EU	European Union
FWL	Frederick Woolley Limited
ICT	Information and Communication Technology
IEE	Institute of the Electrical Engineers
IP	Internet Protocol
IRC	Internet Relay Chat
IS	Information System
ISDN	Integrated Services Digital Network
IT	Information Technology
ITPM	Information Technology Process Management
LC	Low Cost
LC VT	Low Cost Virtual Teaming
MRO	Maintenance Repair and Operations
MSN	Microsoft Service Network
OEM	Original Equipment Manufacturer
OJEC	Official Journal for the European Communities
PC	Personal Computer
PSTN	Public Switched Telephone Network

SME	Small to Medium sized Enterprise
TASC	The Automotive Supply Chain network
TCP/IP	Transfer Control Protocol / Internet Protocol
UK	United Kingdom
VC	Video Conferencing
VT	Virtual Team / Teaming
VTASC	Virtual Teaming in the Automotive Supply Chain project
WMCCM	West Midlands Collaborative Commerce Marketplace
WWW	World Wide Web
XML	Xtensible Mark-up Language

CHAPTER ONE

INTRODUCTION

1 Introduction

The world continues to become a smaller and more competitive place as changes in technology, communication and political geography make for a convergence of markets. As the business environment becomes increasingly competitive, companies continuously must look for approaches to distinguish themselves from their competitors. OEMs (Original Equipment Manufacturers) look further for competitive suppliers and continue to trawl globally rather than predominately locally. OEMs seek fewer, cheaper and more sophisticated suppliers who are able to provide a more complete service, for example the production of engineered systems and modules comprising multi-components rather than single component parts [1].

1.1 Background to the Research

These factors have contributed to the consolidation of UK based 1st Tier supply chains and OEM manufacturers, and have made the position of small to medium sized manufacturing enterprises (SMEs) within the automotive component supply industry extremely difficult. Industry consolidation has resulted in fewer players in a global market as competitive forces increase and the SME customers that do exist being geographically dispersed. Economic forces such as cheap foreign imports from countries with low labour costs and fluctuating foreign currency rates have resulted in SMEs finding it increasingly difficult to compete at home or away with a relatively high cost base compared with competitive Far East economies.

Due to the inherent size of SMEs, many operate within limited financial resources, skills and competences resulting in limited economies of scale and scope and an inability to react quickly to these pressures and demands [2].

Traditionally, OEMs adopted adversarial and confrontational strategies in dealing with suppliers and SMEs. Consequences were "exit relationships" where difficult problems with a supplier would mean that firms would immediately turn to another supplier. However, it was realised that manufacturing supply chains needed to change in order to reduce waste, increase quality, reliability and add more value. This resulted in a switch away from traditional adversarial strategies to the development of long-term collaborative relationships between the OEM and the supplier. This new order of supply chain relationships means that those who follow a collaborative approach are more likely to compete and survive than those who do not.

Technology has become a central determinant of economic success and performance of most industries and companies. Inter-firm collaboration could help SMEs to cut through time and space working with geographically remote suppliers, customers and partners. SMEs however, traditionally have a poor grasp of IT and its exploitation due to a lack of skills, financial resources and the attitude of IT being a secondary and supportive discipline. Technology and its use can help to determine a company's competitive advantage and economic success through the added benefits of greater speed, flexibility, reliability, adaptability and improved cost effectiveness. Therefore, IT is a supporting business function in the same manner that good financial management and supply chain management are and thus require focus and the appropriate resource.

The emergence of Internet technology, as an enabler, has changed many aspects of the ways businesses operate. Companies large or small can use the Internet to

communicate with their partners, to transact e-business and provide the opportunities to reach a global audience. The Internet is a network of interconnected computers which provide a relatively inexpensive and easy way to communicate. The World Wide Web (WWW), which sits on the Internet, presents the opportunity for SMEs to access an infinite volume of information, regardless of time or location. The Internet could also provide an infrastructure and be a low cost effective vehicle for collaborative team working.

1.2 Drivers for the Project

The application of IT systems in large and small organisations, and the enabling technology and inter-firm collaboration required to make them truly effective can be difficult, due to issues with compatibility of process / systems, capability, resources and skills. To address these difficulties the author developed, implemented and tested a Low Cost Virtual Teaming (LC VT) Collaborative Toolset and more importantly a Collaborative Architecture or business model for enabling e-business transactions within manufacturing based SMEs. Both the Toolset and the Architecture are supported by a Collaborative Process methodology, containing rules and protocols, for implementing collaborative Virtual Teaming for manufacturing SMEs. These could support the UK government to achieve its target of making the UK the best place in the world for e-business [3]. To a large extent, with a fair macro-economic climate, the large companies can look after themselves regarding IT and e-business; it is the SMEs which need help to fully achieve this goal [4]. Thus, the work undertaken has been targeted at empowering SMEs by utilising IT more effectively and economically.

There are many changes in the industrial environment affecting SMEs. A range of political, technical and societal pressures drive these, including:

1. The emphasis in industrial support by government has moved from the large companies to smaller enterprises. It is believed this is driven by the realisation that large companies will act globally in response to economic pressures, and hence cannot be relied on to continue providing economic benefit and employment to the host country. This, aided by the realisation that SMEs provide the majority of employment and growth opportunities, has seen a refocusing of emphasis on SME industrial support.
2. The increase in technology development cost and complexity has changed the balance between companies undertaking tasks themselves or outsourcing them. This has led to a rethink about what are core competence/activities for any organisation, and a general increase in outsourcing.
3. The changes caused by enhanced consumer requirements, and related increased financial pressures, have resulted in OEM companies looking to purchase "engineered systems" from suppliers, rather than "components". This increases pressure on SMEs to provide a wider range of products, services, skills and capabilities to the OEM customer.

These and other trends are discussed in more detail in the sections that follow.

1.2.1 Requirements in Supply Base

The increase in product complexity has a direct impact on the Original Equipment Manufacturers (OEM) and their component supply chains.

By offering more variety and functionality to the consumer on a continual basis, product life cycles need to be shorter and more responsive to change in order to serve the consumer with new products faster. More sophisticated products usually are more complex to design and manufacture.

To fill product line gaps, address the requirements of more complex products and share development costs, competing brands such as Ford and Peugeot have formed collaborative joint ventures to develop a range of new diesel engines. This is also happening in other industries. For example, Disney Productions, perhaps a world leader in the production of animated films, produced its recent range of films including "Finding Nemo", in collaboration with Pixar Incorporated, a specialist 3D animated graphics technology provider. Disney recognised that in collaborating with Pixar, it could utilise new skills and know how and deliver a more technically sophisticated and ultimately desirable product than it could do alone. In these examples, significant market players, Ford and Disney are collaborating with competitors or smaller organisations with particular expertise, in order to provide highly competitive products.

However, there is still a culture of control in manufacturing component supply chains. For example, during the Autocle@r project, (see Submission 3a "Background and Development of Virtual Teaming"), a number of Web-EDI systems were evaluated and assessed. Many of these communicated data in only one direction, from the OEM down to the suppliers; there was no facility to reverse communication (and thus no

collaboration!). In reality this high technology Internet-based solution provided little advantage over using established FAX machines.

1.2.2 Customer Requirements

Consumers are more demanding than ever, requiring a wider and more customised range of goods and services. In the automotive industry, for example, new cars are being offered with higher levels of standard equipment and consumer-defined options than ten years ago. Equipment such as anti-lock brakes, air conditioning and power steering are standard on all but the most basic new models. Ten years ago these would be regarded as standard equipment only for the premium end of the market. This move from order winners to order qualifiers, the transition from optional equipment to standard equipment, is being influenced by consumers having greater expectations from manufacturers.

Furthermore, automotive manufacturers, like those in many other industries, are seeking to differentiate their products through market segmentation and subsequent design and production of niche products. This has resulted in the proliferation of manufacturers offering different niche vehicle types such as SUVs (Sports Utility Vehicles), Coupes and MPVs (Multi Purpose Vehicles)

A more technically sophisticated and complex niche product needs a broader range of skills and competences to design, manufacture and support it. Resource requirements are higher and businesses therefore need to possess a range of managerial, financial and technical competences to deliver them. This complexity of modern engineered products has made it virtually impossible for a single company to be able to undertake

all aspects of product design, marketing and delivery. In terms of SMEs' this is the need to move from providing "components" to providing "engineered systems". Collaboration with complementary partners is increasingly essential to allow businesses to offer products that meet the needs of demanding customers.

Early on in the research it was recognised that the demands of providing "engineered systems" are significantly different from providing individual "components". As OEMs and 1st Tier suppliers continue to reduce their number of suppliers, in order for SMEs to compete a wider knowledge set is required. If SMEs want to retain and/or expand their "component" business, they need to be able to apply this "broader knowledge set" to their operations and offer services in addition to greater technical capability. The identification of complementary and compatible partners and working collaboratively with them is their best means of achieving this.

1.2.3 Drivers Summary

In summary, therefore, it can be said that SMEs operate in an increasingly competitive global market and need to deliver more complex engineering systems and more complete services to their customers. An inter-firm collaborative working approach could allow manufacturing SMEs to share product development costs, access, strengthen and broaden core competence, add value and capture new business opportunities, thus resulting in the provision of a more complete and attractive service to OEMs with opportunities to exploit the economies of scale. To deliver these they would need to collaborate and work closely with complementary suppliers, customers and partners. Constraints of cost, time and geographic separation mean that the work would need to be done quickly and efficiently regardless of location, with a reduction

in non-value time and cost. The use of Internet technology could provide the linkages between the needs of SMEs and the requirements of collaborative working through technologies such as Video Conferencing and Instant Messaging. The use of Virtual Team working could facilitate the formation of collaborative team working through providing the methods and tools to enable effective geographically dispersed teams to work together.

Research conducted previously for Rover / BMW Group as part of a Masters Degree in Engineering Business Management by the author, identified issues in developing IT systems and methodologies (see Submission One). Learning points pertinent to this work showed that SMEs struggled with the systems deployed and enforced by Rover / BMW, a typical issue when dealing with OEMs. In particular, a large proportion of the cost of such systems were passed on to the SME and their inferior system hardware and infrastructure struggled to cope with the demands of the OEM system where the systems themselves only considered the information flow down from the OEM. For example, in EDI (Electronic Data Interchange) order systems, the electronic confirmation of orders status and potential order shortfalls were not electronically fed back to the OEM. Hence in this example the issues surrounding the implementation of a collaborative relationship were poorly understood and could have resulted in a relapse to adversarial relationships.

It became apparent that the IT systems developed by the OEMs did not consider the requirements of collaborative partnerships and the constraints SME's had with resources and IT. This research helped towards understanding the attitude that large engineering OEMs have towards their SME suppliers, who are ultimately driven by

the demands of the larger companies. A new approach to enable SME's empowerment to partially control and deal with these constraints and therefore to influence the situation was identified. The SMEs may not be able to completely control the OEM and the industrial environment, but they could compete and collaborate on an equal footing through the provision of technical infrastructures.

1.3 Aims and Objectives of the Research

The aim of the research is to facilitate manufacturing based SMEs, serving the component supply sector, to progress from manufacturing single component parts to engineered systems.

The requirements, identified via SME interviews, Virtual Teaming literature and a technology review, included the reduction of cost and project times through to the adoption of online collaborative working practices. A relevant SME solution would need to be low cost and operate within technical constraints of limited skills, hardware and infrastructure.

The purpose of the research was to develop an inter-firm Collaboration Architecture, a toolset (containing a number of Internet technologies) and set of processes or guidelines for manufacturing based SMEs. Inter-firm collaboration will be defined as multiple small organisations (typically 2-4) working as a team to address engineering and product requirements for a new market opportunity. Key emphasis is placed on the terms small (Small to Medium sized Enterprises), team (the work is interdependent) and manufacturers (the research is focused on the work of engineers not managers). However, typically in small manufacturers the roles of managers and

engineers tend to be combined since the manager will engineer as well as run the business. The research question thus was:

"What type of IT architecture, process and tools are required to support collaboration amongst manufacturing based SMEs, with a goal of business enhancement, and how can it be delivered?"

The research presents opportunities for competitive advantage through wider market exposure and higher overall e-business capabilities, in addition to generic collaborative benefits such the ability to access and strengthen core competence. The objectives govern the technology requirements and the path of the technology review and development.

To fulfil the need for businesses to provide more capability, the objective of the Engineering Doctorate (EngD) portfolio was set as:

"to facilitate the transition from 'components' to 'engineered systems' through a collaborative approach enabled by provision of Internet IT systems, methods and an overall technical architecture to support the needs of manufacturing SMEs within the automotive component supply chain."

1.4 Research Structure

The Executive Summary presents the results of several years' work investigating the use of Information Technology, (particularly technologies associated with the Internet) to aid small to medium sized manufacturing enterprises (SMEs). The aim of the

research work is to develop a process, supported by Internet technology, which could facilitate inter-firm collaboration between manufacturing SMEs within the automotive component supply chain. In particular, the emphasis is on collaboration between manufacturing SMEs through the use of Internet technology, processes and Virtual Teaming.

The methodology and practice is split into three distinct parts:

1. The development of an IT infrastructure to help manufacturing SMEs prosper through finding new business opportunities and finding complementary partners to facilitate the added value work and creating and supporting collaboration activities.
2. An investigation into the capability of manufacturing SMEs and the development of a set of inter-firm processes to facilitate practice and technology using Virtual Teams.
3. Research into Internet Technology and the development of a Virtual Teaming tool kit to enable inter-firm working.

Summarising these points, the author has concluded that:

"SMEs who have access to a Collaborative Architecture to find new sources of work, who form partnerships to pool their expertise to help undertake it, who have the know how to form effective Virtual Teams and can access low cost tools to support virtual working are more likely to succeed through offering a more complete service to their larger OEM customers."

Three main projects were conducted as part of this research. These were undertaken in two stages. The first stage projects, with an approximate of value £400k, were:

1. AutoLean III – a project to introduce Internet Capability into the typical automotive SME (85 SMEs in total).
2. Autocle@r – a project to introduce and test advanced Internet Technology and processes in the automotive supply chain (20 SMEs in total).

These initial projects helped secure follow on funding of over £3.6m for a second phase project which in turn has contributed to the innovation and learning described in this research. The West Midlands Collaborative Commerce Marketplace (WMCCM) is an integrated e-business infrastructure project for enabling West Midlands manufacturing SMEs (over 1,500 SMEs to date) to facilitate finding new business and complementary partners, whilst creating and supporting collaborative activities. WMCCM brings together the outputs of the research from the AutoLean III and Autocle@r projects through an integrated business model.

The result of this research has been a new model for encouraging and enabling collaboration between SMEs, suppliers, customers and the whole SME support industry.

1.5 Executive Summary Structure

The successive chapters will discuss the various aspects of the research work.

1.5.1 Chapter Two, Research Methodology

Describes the research process, its methodology and the techniques employed, the literature and data reviewed and how the validation was carried out. Furthermore, the structure of the portfolio and its overall theme of inter-firm collaboration and sub themes of Internet technology, SMEs and Virtual teaming and the relationship with the portfolio submissions are shown.

1.5.2 Chapter Three, Collaborative Architecture

Its background and how it uses an e-marketplace approach driven by market consolidation within the automotive component supply chain. Additionally, the evolution of automotive e-marketplaces and their impact on manufacturing SMEs are described. The Collaborative Architecture as a new business model is presented combining new business opportunities, partner matching and teamworking for SMEs.

1.5.3 Chapter Four, Collaborative Processes

The development of a methodology for the implementation of collaborative working using a virtual teaming approach is discussed together with the validation activities on various projects.

1.5.4 Chapter Five, Collaborative Toolset

Describes the technologies to enable collaborative working. The use of Internet technology such as video conferencing, instant messaging as collaborative tools are developed and validated on a number of projects.

1.5.5 Chapter Six, Innovation and Discussions

This explains the different aspects of research work and their implications for academia and industry. A number of SME case examples are provided to highlight

business benefits, in addition to the ongoing application of the work on various new projects.

1.56 **Chapter Seven, Conclusions and Further Work**

This looks to establish conclusions and discuss further work recommendations, some of which are currently being implemented.

1.6 Summary

This chapter has shown that an opportunity for the growth and development of SMEs exists through the development of collaborative capability. The key message is captured eloquently in BT's recent television advertising campaign: "more connections, more possibilities." Collaborative capability is a key to good IT systems and can result in improved business performance. Such an approach can be taken through the use of Virtual Teaming and the use of Information Technology and in particular the use of Internet technology capitalising on its growth and proliferation. However, there are many issues surrounding the successful use of IT, so it is important to follow a set of rules and practices. These issues are discussed in detail in the succeeding chapters. The Research Methodology adopted, and the detailed objective derived, is discussed in Chapter Two.

CHAPTER TWO

RESEARCH METHODOLOGY

2 Research Methodology

The EngD focused on two main topics. Firstly, the drivers, considerations and obstacles to enabling effective collaboration among manufacturing based SMEs serving the component supply sector, and secondly the application of IT systems to support effective teamwork among partners on engineering projects.

This Portfolio demonstrates how the research made an important and significant contribution to ICT development and implementation of inter-firm collaboration for small manufacturing based businesses. The research has taken into account the business processes, the culture and the IT systems. Specifically, it has considered the use of Internet technologies within the automotive supply chain to address basic business problems.

2.1 Development of the Methodology

This research has two parts to the development of the research methodology, the research approach taken and the structure or plan and model followed.

2.1.1 The Research Approach

There are two distinct research philosophies, positivistic and phenomenological.

2.1.1.1 Positivistic Approach

A positivistic philosophy seeks facts with little regard to the subjective state, focusing on logical reasoning rather than experience and intuition. This type of research philosophy does not affect the subject directly or immediately and is conducted away from the research field. It is based on quantitative, scientific and formal research, conducted independently and from a distance and is objective in its viewpoint. In

short, the positivistic approach believes that "the act of investigating reality has no effect on that reality" [5]. This is directly at odds with the aims and objectives of this research, which is to investigate reality and to directly influence and change that reality in order to affect a movement from the problem to a realised solution. This point of view also sits well with the principles and requirements of the EngD.

To paraphrase from the EngD Handbook, the "EngD is aimed at developing individuals who not only innovate but can implement that innovation" [6]. Therefore it became apparent early on that this approach was not relevant to this work.

2.1.1.2 Phenomenological Approach

A phenomenological philosophy framework looks to the subjective rather than the objective. It combines elements of interpretation, observation and other qualitative techniques rather than formal quantitative measures. More importantly, the researcher is directly involved in that which is being researched and examined, and has direct interaction with the research subject. Since the research was in part conducted in the workplace, data was qualitative based upon information. Through using an array of interpretive techniques and different perspectives, balanced reasoning can be achieved. This philosophical framework fitted in well with the aims and objectives of this research i.e. collaboration and co-operation, and would form the design framework for the research methodology and model.

It should be noted however that a criticism of the phenomenological approach is that although validity is high, too much emphasis is placed on the subjective side of the research rather than the quantitative. To address this, a continuous learning and

progressive model development method was followed, where continuous feedback of up to date information and model refinement would seek to ensure that research integrity remained high. With this in mind, various methodologies that work well with the phenomenological philosophy were considered.

A mixed methodology approach was taken to give a broader and complementary view of the issues and ensure balance within the research to gain a more comprehensive understanding of the issues. This approach also encourages and enhances a phenomenological approach and is integral to good research design, giving data integrity. This mixing of methodologies ensures triangulation and leads to a greater validity, quality and reliability than one single approach. This is important as it will ensure that the qualitative aspect of the research is rigorous and robust.

Therefore the research design contained within a Phenomenological philosophy incorporated the following methodologies - Grounded Theory, Participative Enquiry, Applied Action Research, and Case Studies.

2.1.1.3 Grounded Theory Methodology

Grounded Theory is the ability to build a methodology which seeks to highlight the area under investigation. The aim is to arrive at findings and recommendations through a solution which is able to be understood and be useable by those within the industry dataset. It allows them to comment and feedback, through their insights, into the model thereby ensuring the solution's relevance.

Grounded Theory approach was practised because the author alternated between inductive and deductive research. This was achieved through actively gaining information from the field through a number of structured and unstructured interviews with practitioners and implementing collaborative technologies within organisations. A deductive analysis was then conducted when the author rationally considered the missing gaps and formed conclusions whilst away from the field. Finally the author reverted back to the field to test the tentative conclusions, thus grounding the theory. This process was repeated many times.

The methodology adopted concentrated on considering the issues surrounding collaboration from both large and small organisation's perspectives within the supply chain. This has generated an understanding of the environment and culture in these types of organisations. Such understanding is critical in order to build effective IT systems which link these types of organisations. Since external understanding of a company culture is difficult, the approach was taken of being assimilated into a large organisation as an employee, and then establishing strong working relationships with the smaller companies through meetings, visits, implementations, and workshops. This approach proved to be both essential and rewarding.

2.1.1.4 Participative Enquiry Methodology

Participative enquiry is a methodology which involves the participants as fully as possible in the research and is conducted within the research field. Participants are able to debate and determine the progress and direction of the research. The overall nature of the EngD research concerns collaboration and cooperation, therefore participative enquiry is an appropriate way to bring these elements into the work. This

approach is different from Grounded Theory in that the latter can be conducted remotely or through workshops, where as Participative Enquiry allows the participants to be directly involved. Therefore this ensures validity, relevance, accuracy and quality, instilling a sense of belief within the solution.

2.1.1.5 Applied Action Research Methodology

An 'applied action' research approach within this methodology approach brings the ability to focus on a specific existing problem and initiates an effective method in bringing about a conscious change in practices, by applying the findings to industry. The terms central to this approach are 'improvement' and 'involvement' in that there is a learning environment and a development of competencies. This fits in well with the principles of the EngD, as it looks to both Academic and Industrial relevance in research work.

A consequence of this approach is that the research subjects are aware of the changes in practice, and are able to contribute actively and take action from the research findings, realising its potential for business gains early on, thus keeping the research relevant and dynamic. This approach combines well with participative enquiry since the participants are involved directly and so the conscious changes are more immediately relevant to them. The collaborative nature of the applied action research method bodes well with the overall research philosophy which looks to stress the benefits of collaboration and co-operative working. Applied action research is similar to a case study approach, adopting many of the same principles and therefore these two approaches are complementary and combine well to get the best results.

Applied Action research facilitates contribution to knowledge within the field of collaborative technology and methods. The applied action was geared to creating change in working methods and practices. The author was a participant in the change process rather than an observer.

2.1.1.6 Case Study Methodology

Case studies were used as a method of research in this holistic research approach. They focus on understanding the dynamics present within the industry dataset and measuring its impact on particular projects, watching the changes and reactions and taking the observations made and feeding them back into the original model. This enables the model to undergo a continuous improvement element, where up to date and relevant information and observations are fed back into the model, ensuring a degree of rigour within the methodology. It is also complementary to the principles of grounded theory.

Case studies were used to determine issues surrounding the use of collaborative systems and to generate data for analysis. A number of conclusions were drawn from the data to develop the theories and concepts, which led to the concept of the Collaborative Architecture, supported by a set of Processes and a Toolkit. These concepts are discussed in detail in the following chapters.

The case studies provided an examination of the subject area within the automotive industrial setting. The automotive industry is driven by and is conducive to innovation because of intensively competitive pressures. It operates in a worldwide market and has a constant drive towards lower costs. It is an extremely important

sector for the local West Midlands economy, and for many other regions and countries.

2.1.1.7 Predictive Research Approach

Finally, a predicative research approach was applied to allow emerging themes and technologies to be considered, so that the research work has an element of longevity. This is particular relevant in the area of collaborative working since supply chain structures in manufacturing are dynamic and solutions proposed, particularly IT solutions, must be robust. This viewpoint leads to the future work discussion in Chapter 7.

2.1.1.8 Summary of Research Approach

In summary, the research methodology has been based around a phenomenological philosophy in order to directly address and influence the research issues. This dictated a close interaction with many organisations working within the field, and the use of several research methods to gain balance and rigour. Additionally, feedback from the field resulted in improvements were required, keeping the model up to date and relevant.

Now that the research approach had been determined, it was appropriate to plan and order the research work. Therefore the next step in the development of the research methodology was the development of the research structure.

2.1.2 Research Structure

Data from three key areas were fed into the model and tested on a number of initial projects to test different parts of it. The model was then tested on a number of projects to determine its effectiveness and the results fed back and changes made were

necessary. The refined model was subsequently used to develop and argue a case for follow on work and public funding where validation activities of the work were undertaken. This structure can be seen in Figure 1.

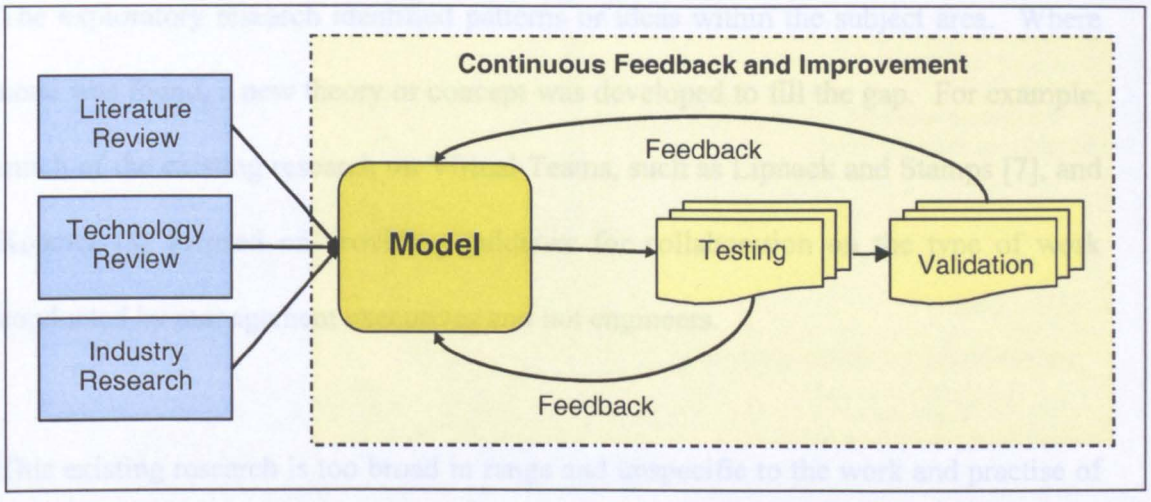

Figure 1 – Research Structure Schematic

A summary of the structure, scope and significance of the research methodology is presented in Table 1 and is discussed in the following sections.

	Scope	Activity
Literature Review	Collaboration Practices Collaboration Techniques	Review of Virtual Teaming and working practices for manufacturing based SMEs
Technology Review	Collaboration Tools	Review of collaborative technology for manufacturing based SMEs
Industry Research	Go4gain Business Directory Accelerate Partners	Manufacturing based SMEs serving the component supply sector within the West Midlands region of the UK
Develop Model	Collaborative Architecture Collaborative Processes Collaboration Toolset	Development and proposal of a collaborative business model comprising Internet technology and set of practises and rules.
Test on Sample	Autocle@r (20 SMEs & 2 first tier suppliers), TASC Net (10 SMEs), AutoLean II (80 SMEs)	Number of public funded research projects during initial phase of research to determine and develop practices. Results fed back into model
Validation	Validation - WMCCM (currently 1500 SMEs), regional stakeholders, Conference Papers and Journals	Validation (and further testing) of proposals via implementation within SMEs, acceptance of model with bodies such as trade associations and publishing of papers.

Table 1 – Research Structure Summary

2.1.2.1 Literature Review

In terms of developing the methodology, academic literature, technology and industrial practice were studied to determine suitable theories and concepts.

The exploratory research identified patterns or ideas within the subject area. Where none was found, a new theory or concept was developed to fill the gap. For example, much of the existing research on Virtual Teams, such as Lipnack and Stamps [7], and Kostner [8] focused on providing guidance for collaboration on the type of work conducted by management executives and not engineers.

This existing research is too broad in range and unspecific to the work and practise of engineers, where this research is directed. Therefore, new guidelines and a methodology were developed for engineers working within manufacturing based SMEs to address this gap, taking into account their specific requirements. In particular, the Virtual Teaming equipment was considered by much of the literature to be too expensive for small manufacturing based SMEs. For example, it is difficult to justify a month's trial of studio based video conferencing equipment when it costs approximately £250. Working with the companies made it possible to understand their requirements, constraints and limitations and to establish their parameters for the most appropriate plan of action.

The current position of many SMEs making 'components' and their relationship with their customers can be evaluated by using the "Interprise Relationship" model, proposed by Preiss [9], a method of mapping the evolving relationships in supply chains. This model is shown in Figure 2. According to Preiss "An Interprise exhibits

increased integration with the business processes of customers, more co-operation with suppliers, and an entrepreneurial internal environment" [9, pp.4].

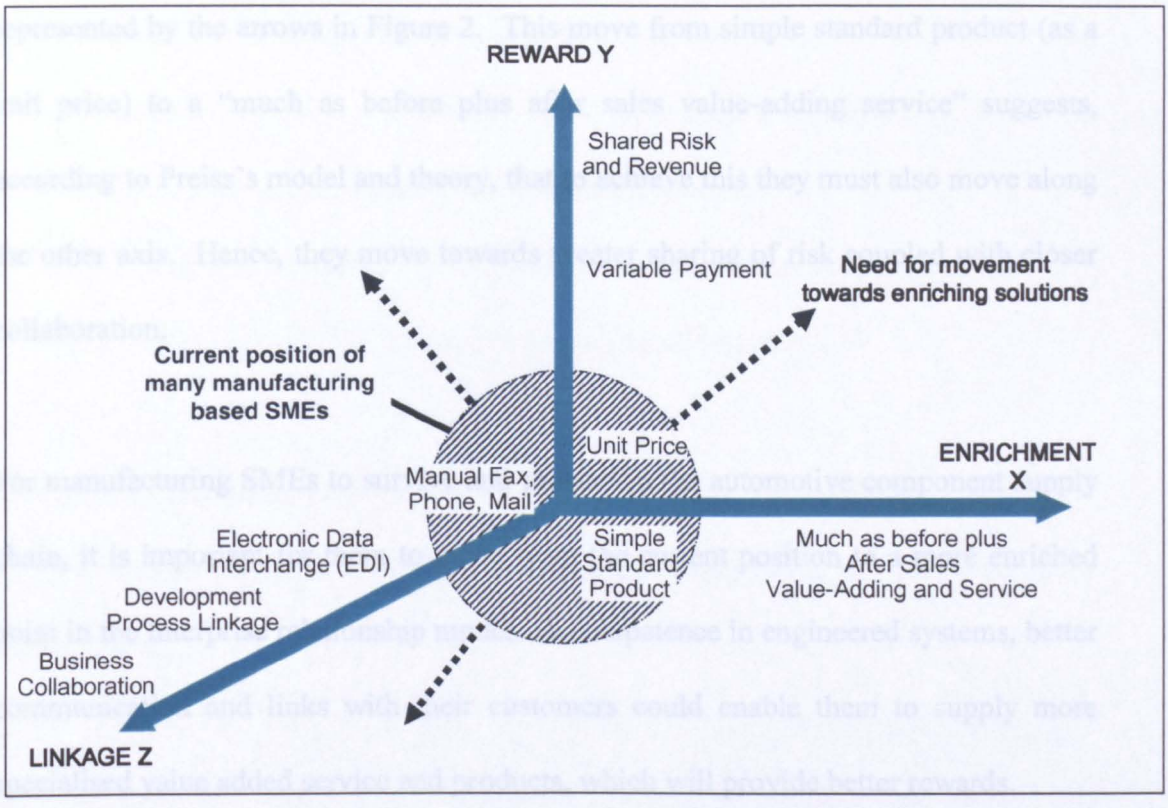

Figure 2 - The Interprise Relationship Model

Source: Cooperate to Compete, Preiss, K., Goldman S. and Nagel, R., 1996, pp.113 [9]

In the "Interprise relationship" model, illustrated in Figure 2, the "X axis" represents what the supplier offers the customer, the "Y axis" represents what the customer offers the supplier and the "Z axis" represents how the customer and supplier are linked together. To achieve the models goal and become enriched, progress can only be achieved if movement takes places on all three axes and change take place steadily.

Many West Midlands automotive supply chain SMEs sit near the origin or centre of the axis since they offer limited products and service, sell on unit price, and have limited effective integration with the rest of the supply chain through linkages such as

FAX and mail. However, demands from their customers to move from "components to engineered systems" means that they must move along the horizontal axis represented by the arrows in Figure 2. This move from simple standard product (as a unit price) to a "much as before plus after sales value-adding service" suggests, according to Preiss's model and theory, that to achieve this they must also move along the other axis. Hence, they move towards greater sharing of risk coupled with closer collaboration.

For manufacturing SMEs to survive and prosper in the automotive component supply chain, it is important for them to move from the current position to a more enriched point in the Interprise relationship model. A competence in engineered systems, better communication and links with their customers could enable them to supply more specialised value added service and products, which will provide better rewards.

Literature research was conducted within Submissions One, Two, and Three of the research portfolio, so that current thinking within collaboration could be identified and understood. A number of database sources were used for this purpose, of which a small selection follows:

- Compedex Service - literature database available via the Internet.
- EBSCO - literature database available via the Internet.
- Economist Business Database – online general business and economic resource.
- Index to Thesis – University of Warwick library resource of PhD reviews.
- OPAC - the University of Warwick Library system.

- ProQuest Direct - literature database available via the Internet.
- Science Direct - literature database available via the Internet.
- www.cw360.com - online IT news, reports and information.
- www.silicon.com – online e-business news, reports and information.
- www.virtualteams.com – online Virtual Team resources.
- www.virtualteamsresearch.org - online Virtual Team research and resources.
- www.vnunet.com – online IT news, reports and information.

Within these databases, both journals and business books were accessed. The quality of the literature reviewed for the EngD varied according to the size and type of the organisation.

For example, for large OEMs there were many good articles that covered the development of IT systems, methodologies and techniques such as that of Clegg [10] and Holmes [11]. In contrast, for smaller companies there was a shortage of material that covered the relevant aspects and there was a lack of formal analysis. Specifically, the problem of limited Information Technology capability and approach to e-business within SMEs is an issue that became an area for concern. The poor quality of literature for SMEs was evident during the EngD research, with repeated requests by software vendors approaching the author to write a case study on how small companies could adopt and use e-business, due to their inability to find relevant information amongst the available 'knowledge'.

Furthermore, understanding the requirements of small business was critical to the success of the project, but the lack of literature provided an opportunity to understand and fill the gap. There has been a lot of research and many initiatives by governments on small businesses and business performance. For example, the G8 Global marketplace for SMEs project started in 1996 which recognised the importance of SMEs and tried to identify mechanisms to e-enable them and make them more competitive [12]. However, a gap was still evident in the use of collaboration tools and technologies within small manufacturing based companies. Therefore, a key part of the research was to undertake a literature review and develop a methodology specifically for small manufacturing based firms.

2.1.2.2 Technology Review

A technology review was undertaken to in order to develop a technology solution to enable collaborative working. The solution aimed to capitalise on the proliferation of the World Wide Web and Internet infrastructure, through the provision of an Internet technology based solution for small companies to undertake collaborative working practices using a Virtual Teaming (VT) approach.

The user (customer) requirements identified for the system were:

- Low cost or free.
- Audio and Video Conferencing.
- Collaborative tools such as a virtual whiteboard, shared application capability, file transferring and Internet Relay Chat.
- Compatibility with existing systems.

- Ability to work with low or restricted bandwidth.
- Technical support and active product development from the vendor to ensure longevity.

There is considerable prior research work in the Virtual Teaming area, both theoretical and practical, with the benefits of such methods of working widely recognised [7, 8, 13, 14, 15, 16, 17, 18]. However, previous Virtual Teaming research was used primarily within large corporations who can afford the technology and infrastructure required; often an expensive technology that SMEs cannot afford.

The research work investigated and developed technologies that can enable SMEs to undertake Virtual Team work with other companies at low cost and with limited technical ability. This involved project planning and task identification, and interviews with a number of SMEs to determine their requirements and user issues. This was achieved through a number of structured and unstructured interviews with practitioners in the field, implementing systems with a sample number of practitioner SMEs and actively gaining information. Deductive analysis resulted in the author considering next the missing gaps and forming conclusions whilst away from the field. The author reverted back to the field to test the tentative conclusions thus grounding the theory. This process was repeated a number of times.

For example, in order to ascertain what was the most appropriate collaboration system for manufacturing based SMEs, a technology selection process was undertaken in a number of stages. Sixty-four products were evaluated and a high-level assessment carried out to determine their suitability for the SME through factors such as

collaborative requirements, inherent limitations and constraints. A second step saw the SME participate in a QFD (Quality Functional Deployment) evaluation to systematically assess the relative importance of customer requirements of a product against its technical features and functions.

2.1.2.3 Industry Research

The research captures the essence of the phenomena and extracts data which was rich in its explanation and analysis. To ensure that the data was applicable, an empirical approach was taken resulting in much interaction with real companies. This was carried out through collecting evidence from many visits and interviews with manufacturing based SMEs predominately serving the component supply sector, and combined with the development and implementation of collaborative tools and engineered systems with the SMEs.

This dataset therefore describes where the source of data was from and where the research is focused. The dataset was based on the use of collaboration and inter-firm relationships across the supply chain, using Internet Technology to support these relationships. This data was taken from a regional online business directory called go4gain (www.go4gain.co.uk) and the West Midlands automotive initiative, Accelerate. The go4gain business directory in particular contained a varied group of companies across different sectors and industries, although predominately SMEs and with an engineering or manufacturing basis. Although there was much variance within the dataset, it is important to note that they still have a pre-disposition to collaborate and supply higher value systems rather than simple low margin components.

The Automotive Industry focused dataset was selected since, in many regards, it is considered at the cutting edge of manufacturing and operates within a worldwide market. It can be regarded as a leader that many other industries learn from and follow. Indeed Peter Drucker, a management author, coined automotive as the "industry of industries" [19]. Other industries, especially service orientated, are attracted by the rigor and analysis that goes into designing and operating manufacturing processes within the engineering industry and automotive in particular.

2.1.2.4 Develop Model

Through the establishment of the research task, aims and objectives, and the identification of the gaps in literature, the innovation field was identified. As a result, the overall research direction was established, research process formalised and resultant gaps made into proposals.

Key phases of the research were spent within both a large organisation and many SME businesses. Development of a collaborative system for SMEs provided a solution to fill the gap in the literature and also an innovative solution for collaborative working within the manufacturing based SMEs. This is discussed in more detail within Chapter Four.

The proposals were based upon creating an online electronic "Chamber of Commerce" through an e-marketplace approach. A Chamber of Commerce is an association of business persons whose purpose is to promote commercial and industrial relationships in the local community. A goal is to build trust between the

entities through contact and membership of a common organisation. Another is to promote information and knowledge sharing, regarding opportunities and resources. Many of these processes and activities could be replicated online and made available 24 hours a day to reach a wider and larger audience. Members would not need to wait for their next meeting or be restricted to accessing members in their immediate locality.

This overall business model is illustrated in Figure 3. It firstly shows an overall SME business process and secondly the Collaborative Architecture containing a Toolkit and Collaborative Processes (guidelines).

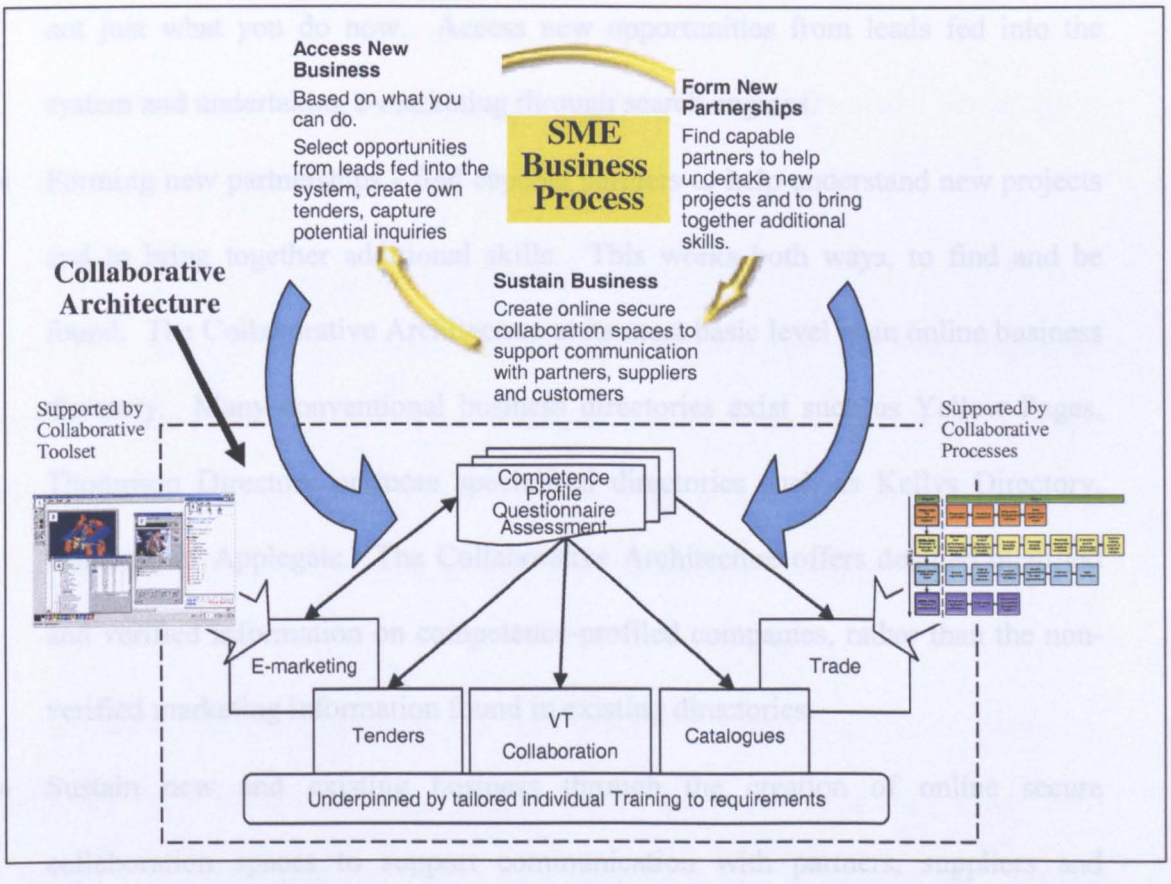

Figure 3 - Collaborative Architecture Business Model

The key driver for the collaborative model is the desire for SMEs to have access to and generate new business opportunities, as shown at the top left of the model. This is

a fundamental need of all business, however, the collaborative model proposal presents new opportunities to e-trade, opportunities which otherwise would not be easily available to small business.

The three elements of the collaboration model will be discussed in detail in the following chapters. The collaborative model, an iterative process, underpins the regional e-marketplace model and is based upon the process of achieving these overall business goals:

- Accessing new business - the start of the model cycle, based on what you can do, not just what you do now. Access new opportunities from leads fed into the system and undertaking e-marketing through search engines.
- Forming new partnerships - find capable partners to help understand new projects and to bring together additional skills. This works both ways, to find and be found. The Collaborative Architecture at its most basic level is an online business directory. Many conventional business directories exist such as Yellow Pages, Thompson Directory or more specialised directories such as Kellys Directory, Compass or Applegate. The Collaborative Architecture offers detailed qualified and verified information on competence-profiled companies, rather than the non-verified marketing information found in existing directories.
- Sustain new and existing business through the creation of online secure collaboration spaces to support communication with partners, suppliers and customers. This part of the cycle would then potentially lead back into the model through the partners building on project's success and seeking new business opportunities.

From the review, proposals and validation this research makes a contribution to knowledge regarding SME collaboration in three key areas:

1. Architecture - how many SMEs can participate in an affordable way and what functionality do they need?
2. Process – how SMEs can use the collaborative systems effectively to undertake core business activities?
3. Toolset – what Internet Technology tools do SMEs need to collaborative effectively?

These three main aspects of the proposed collaborative business model Architecture, Processes and Toolset, are illustrated in Figure 3.

2.1.2.5 Testing and Validation of Model

Four key industrial projects were undertaken during the research; each played an important part in the testing and subsequent validation of the model. These projects were samples of the industry data set. Samples were selected to represent a balanced sample of SMEs with typical characteristics, issues and requirements.

It was found that the automotive manufacturing based SMEs served many diverse industrial sectors such as white goods, leisure products and DIY. Other non-engineering or manufacturing companies studied included, for example, the Gas and Water National Training Organisation where an investigation was carried out on how

seven remote programme managers could be managed and connected into their headquarters through the use of synchronous technology.

Thus, the sample companies varied considerably in terms of their overall business requirements, experience of collaboration, maturity of their IT systems and IT skills.

2.1.2.5.1 Test on Sample

The three collaborative research areas - the architecture, processes and tools – were mainly tested independently on three different public funded industrial projects.

In the Autocle@r project twenty SMEs were introduced to new collaborative ICT tools. Primarily the Low Cost Virtual Teaming (LC VT) system was developed and tested. This incorporated synchronous communication technologies including video conferencing, electronic whiteboards and Instant Messaging, all of which were new to the sample SMEs. A guide to the implementation of the LC VT system was also developed through a Participative Enquiry approach with the SMEs. This, for example, involved direct interaction with the SMEs through meetings, study of their requirements, and installations of the LC VT system and feedback of the proposed system through a QFD (Quality Function and Deployment).

Two further datasets were selected for the investigation of Collaborative Architecture. It was imperative to study a group of SMEs who already worked together, had a disposition for collaboration and had already adopted basic Internet technology such as email. This research was conducted via the AutoLean III and the TASC Net projects. These evaluated the key factors for online communities and asynchronous

communication tools within forty automotive SMEs. The competence profiling process, used with the Collaborative Architecture to present skills and capability, was refined and further tested in the second part of the AutoLean III project.

The research objectives resulted in the author being granted participation in three public funded programmes to aid manufacturing based SMEs. These projects were used to test the subsequent methodology and feed back into research work.

2.1.2.5.2 Final Validation

Validation of the work came through two distinct areas. Firstly, validation was through the acceptance of academic work undertaken through publishing of papers, presenting and questioning at academic international conferences and publication of conference proceedings. The other area of validation was through the work being used in a number of company SMEs on multi-projects. The overall business model gained £3.6 million in funding for further research and development – this became the West Midlands Collaborative Commerce Marketplace (www.wmccm.co.uk). Validation of the research is discussed in detail in chapter three, section 3.6 and in chapter 6.

2.1.3 Methodology Summary

The development of the research methodology comprises a phenomenological philosophy using a mixed methodology approach in order to give a broader and complementary view of the real business issues. The research data came from three key areas which were fed into the model and tested on a number of initial industrial projects. Data from each project was subsequently fed back into the model and refinements made where appropriate. The model was subsequently used to put

together a business case to secure public funding and validate the model further through academia and industry. The research, development and results of this work were gathered together and formed the portfolio structure.

2.2 Portfolio Structure

The overall research was subsequently broken down into a number of sub themes, which were addressed through individual research submissions. The overall scheme can be seen in Figure 4.

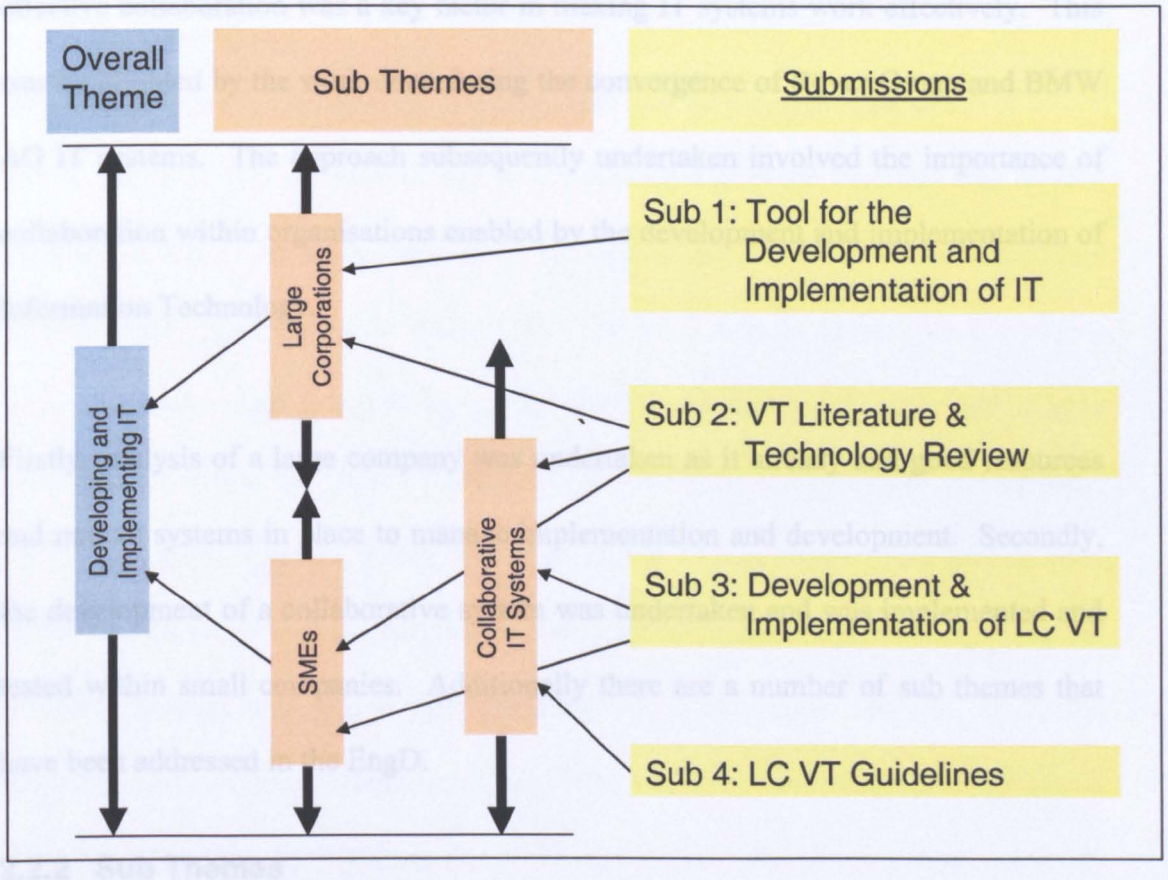

Figure 4 – Map of the EngD Themes and Submissions

2.2.1 Research Theme

The main theme of the Portfolio is centred on improving the interactions between OEMs and their supply base through Inter-firm collaboration. Within supply chains,

many of the lower tier businesses are small independently owned businesses which are very different in organisational structure from their ultimate business customers.

To address and understand the issues within this subject it was important to consider both large organisations and small business needs within a specific industry and their associated use of IT.

The outcome of the initial work undertaken was the understanding that enabling effective collaboration was a key factor in making IT systems work effectively. This was highlighted by the work done during the convergence of Rover Group and BMW AG IT systems. The approach subsequently undertaken involved the importance of collaboration within organisations enabled by the development and implementation of Information Technology.

Firstly, analysis of a large company was undertaken as it already had good resources and mature systems in place to manage implementation and development. Secondly, the development of a collaborative system was undertaken and was implemented and tested within small companies. Additionally there are a number of sub themes that have been addressed in the EngD.

2.2.2 Sub Themes

There were two specific sub themes within the Portfolio; organisational size and inter-firm collaboration. Within the systems with support collaboration, one of the key concepts pursued was how to exploit the use of the Internet and the low cost networking capability it provides.

The tiered supply chain is made up of powerful OEMs and large 1st Tier corporations at the top with many small businesses below. The approach taken through the development of collaborative working is for large and small members of the tiered supply chain to be able to work closely together. To develop and implement new IT systems, such as collaborative technologies seen earlier, is fraught with hazards. SMEs need guidance so they can successfully adopt new ways of working. The research submission structure is as follows:

2.2.3 Submissions

Submission One: A Tool for the Development and Implementation of IT

The objective of this submission and its positioning within the Portfolio was to give the author considerable knowledge of the IT business environment and the approaches used in large organisations to deliver IT. The work was to investigate the use of System Development Methodologies in the Rover Group, a large automotive manufacturer within the United Kingdom and wholly owned by BMW of Germany. At the start of the project, Rover was undertaking a large convergence project with BMW within many business functional areas such as production scheduling, with the 'PS2000' project, and engine manufacturing, the 'Hams Hall' project. Thus, the project described within Submission One, ITPM, concerned the integration of Rover's 'System Development Management Policy' and BMW's 'Project Model' methodologies.

An integral part of Information Systems within large organisations are their relationships and links to the parts lower down the supply chain. On many levels,

there is significant interaction and communication between small suppliers in their supply chain. The exchange of this information, such as production schedule information or new production introduction data, is a fundamental part of both their businesses.

This submission gave grounding to the second submission that set out to review the methods and technologies used in distributed project work teams, and understand the issues and technologies available to conduct work with the supplier base.

Submission Two: A Literature and Technology Review of Virtual Teaming

Many factors had been identified which made IT development and implementation a risky process. Collaboration is a wide area covering many work practices and technologies. A specific focus was needed and therefore the approach suggested was through the use of Virtual Teams.

Virtual Teaming (VT) was emerging as a tool being adopted by organisations in order to gain competitive advantage through collaborative working with remote parties using ICT. However, due to the problems of working with diverse organisations and cultures, VT is particularly difficult to develop and implement. Thus, this submission considered the three aspects of VT, Technology, People and Process. The approach taken was through a literature and technology review to identify an appropriate solution for companies wishing to introduce VT into their organisations.

The ideas developed about Virtual Teams in Submission Two would need to be tested in a real life situation. Additionally, literature about the introduction of Virtual Teams in SMEs is limited, thus it is important to gain further understanding through practical

testing. Due to the complex relationships between large organisations and small businesses and the limited previous work on Virtual Teams in small business, the approach in the next submission was on the application of Virtual Teams within small automotive businesses.

Submission Three: The Background, Development, Implementation and Analysis of Low Cost Virtual Teaming

This submission was broken up into two parts. The objective was to develop and implement a VT solution in Small to Medium sized Enterprises (SMEs). To meet this objective, firstly the requirements of SMEs and collaborative systems would need to be identified so that VT systems could be developed. Secondly, the system would need to be tested within a number of small businesses in the automotive supply chain. The submission focused on an EU funded project called Autocle@r based in the West Midlands region of the UK. The objective of Autocle@r was to identify and enable e-business capability applicable to SMEs. Thus, this submission describes the knowledge gained in undertaking this task.

The practical experience with SMEs implementing Virtual Teaming led to the formation of a set of guidelines for undertaking this task. This activity is described in Submission Four.

Submission Four: A Guide to Low Cost Virtual Teaming

This submission focused upon the process of implementing the Low Cost VT system developed within SMEs. The requirements defined in Submission Two and the knowledge gained during the Autocle@r project, Submission Three, was used in the development of the guide.

The research approach initiated how to improve and structure the interactions between members of the supply chain. This progressed from the general implementation and development of IT, and the methodologies used within a large corporation, to inter-firm collaborative working within small organisations to undertake higher value more complex and collaboratively rich work.

2.2.4 Suggested Order of Reading

The Executive Summary is the first piece of work that should be read followed by the first, second, third and fourth submission within the Portfolio. It was possible for the submissions to be numbered appropriately in the reading order as they were submitted at approximately the same time.

2.3 Summary

In the next chapter, the Collaborative Architecture is discussed. Although the architecture was derived during the later stages of the research work, it is important to discuss this in detail first, since it bonds the other research aspects together.

CHAPTER THREE

COLLABORATIVE ARCHITECTURE

3 Collaborative Architecture

3.1 Introduction

The collaborative business model or Collaborative Architecture, consists of a new form of e-marketplace – the regional e-marketplace. This chapter will give a brief overview and background of its formation, development, status and future work.

3.2 Background

3.2.1 SME Cost Down Pressures via e-marketplaces

The average lifecycle of an automotive component is being compressed by the OEMs who strive to produce new vehicles with ever decreasing life cycles. Within the life of these components, their design and specification are subject to frequent modification and thus interaction between customers and suppliers is critical and recurrent. Delays can be costly and the time wasted in frequent face to face meetings can be significant.

Virtual Teaming literature (see Submission 2) and experience on the Autocle@r project (see Submission 3B) demonstrate that wasted time can occur as a result of:

- Travelling to and from meetings.
- Preparation time.
- Preparing data, reports etc for the meetings at the remote location.
- Difficulties in scheduling a face to face meeting.
- The right expertise may not be accessible during the meeting. For example, it was noted that the use of mobile phones to try to get opinions from back at base during meetings was a regular occurrence.

These difficulties tend to result in long infrequent meetings with many participants. However rich collaboration requires short, focused and frequent meetings. A mixture of physical and electronic meetings could better meet these demands.

For an e-marketplace to serve the manufacturing sector and its engineering companies, it needs to provide robust facilities to support on-line collaboration between supplier and customer and stimulate the building of rich relationships. But what are e-marketplaces and how relevant and appropriate are they for SMEs?

3.2.2 Automotive e-marketplace background

A report by the University of Birmingham on the future of the automotive industry identifies that "there is little evidence that firms are seeking to reposition themselves to exploit the changes that look set to arise from developments in e-commerce. Only a minority of companies are developing, or actively planning to develop, e-commerce strategies." [20]

A series of figures (from Figure 5 to Figure 8), firstly illustrate developments in the automotive e-marketplace arena and secondly propose a business model or architecture to address some of the issues of small manufacturing based firms.

Initial efforts to form online trading places in the automotive industry saw automotive OEMs entering the market and establishing private e-marketplaces exchanges (see Figure 5). This model evolved, as in many other industries, when major OEM players came together and moved to a vertical consortia model. This model often does not totally dominate as some major players decide to go their own way, for example when

VW and BMW formed their own initial exchanges. Recently Covisint [21] consortia members have begun to re-focus on their private exchanges, because of the difficulties making rapid progress whilst in a consortia.

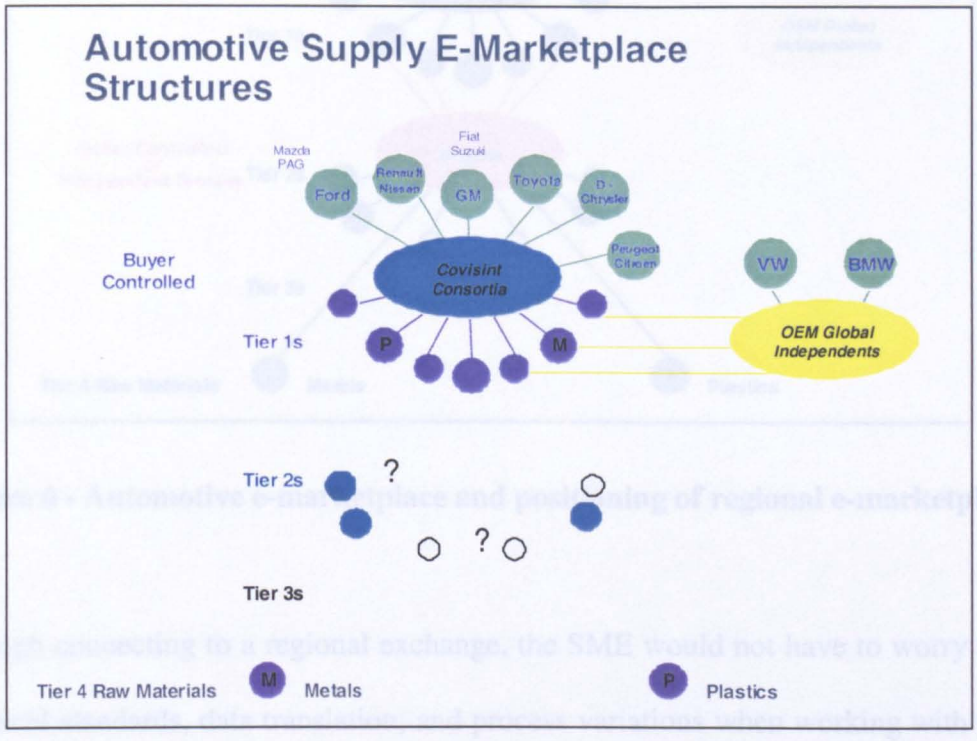

Figure 5 – SMEs within the automotive Supply e-marketplace

For the smaller tier 2, 3, etc companies the supply chain integration problems are exacerbated as they have to work with a range of e-marketplaces. For example, a plastic moulder would buy plastic from the plastic exchange, source tooling from a tooling exchange and manufacture and supply components to a customer via an automotive industry exchange.

The positioning of the regional e-marketplace model in relation to other automotive e-marketplaces is shown in Figure 6.

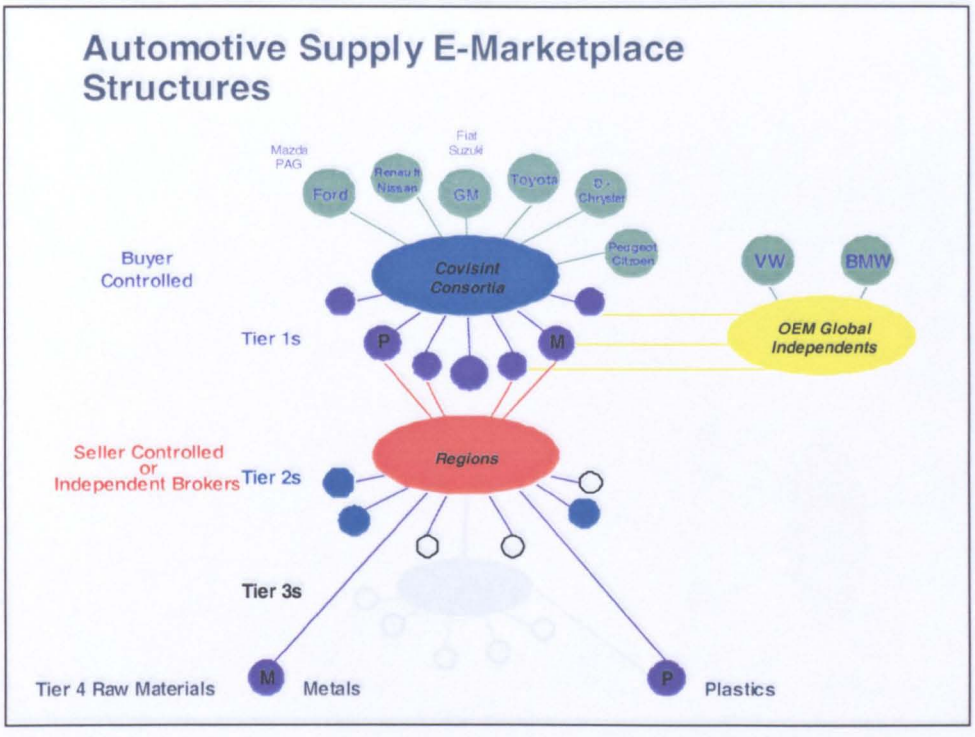

Figure 6 - Automotive e-marketplace and positioning of regional e-marketplaces

Through connecting to a regional exchange, the SME would not have to worry about technical standards, data translation, and process variations when working with many different sectors, suppliers and customers. Furthermore, a regional e-marketplace could allow regional SMEs to connect to other exchanges and major companies in the region.

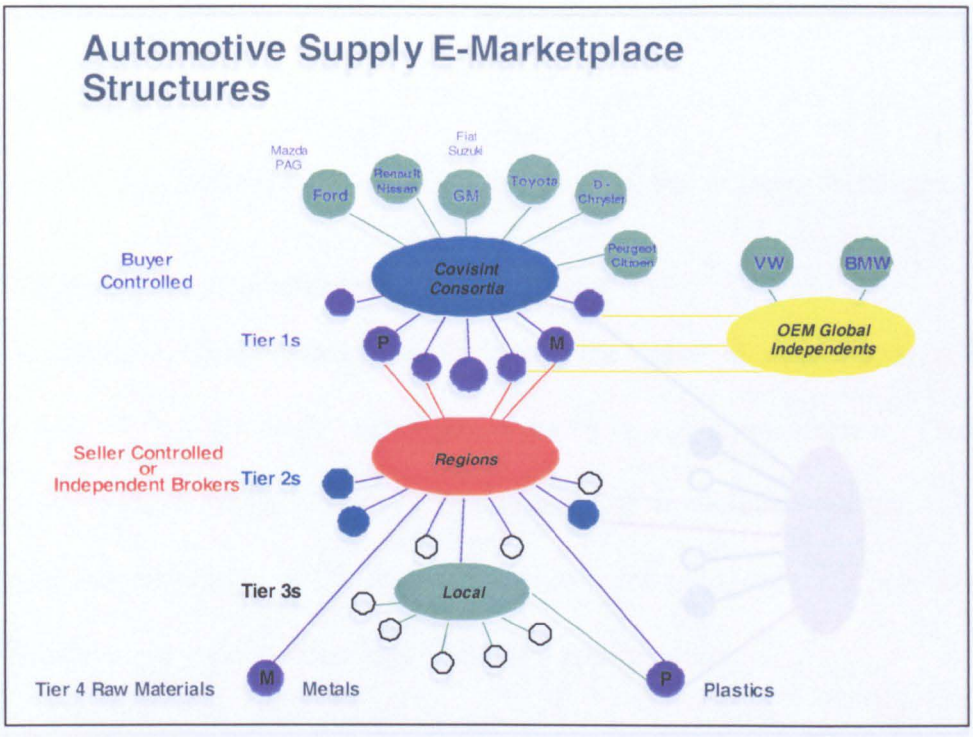

Figure 7 - Automotive e-marketplace & positioning of local e-marketplaces

The regional e-marketplace would support clusters, with a common look and feel and functionality, from within the region (see Figure 7). An example would be a motor racing industry cluster, or a sub-regional cluster, such as an industrial trading estate.

Eventually, exchanges from different regions could connect together to mutually support SMEs (see Figure 8). For example, an automotive injection moulder from South Africa (where there is little automotive support infrastructure) could link with a specialist tooling provider in the West Midlands, where the infrastructure exists, but has consolidated OEM and 1st Tier manufacturing.

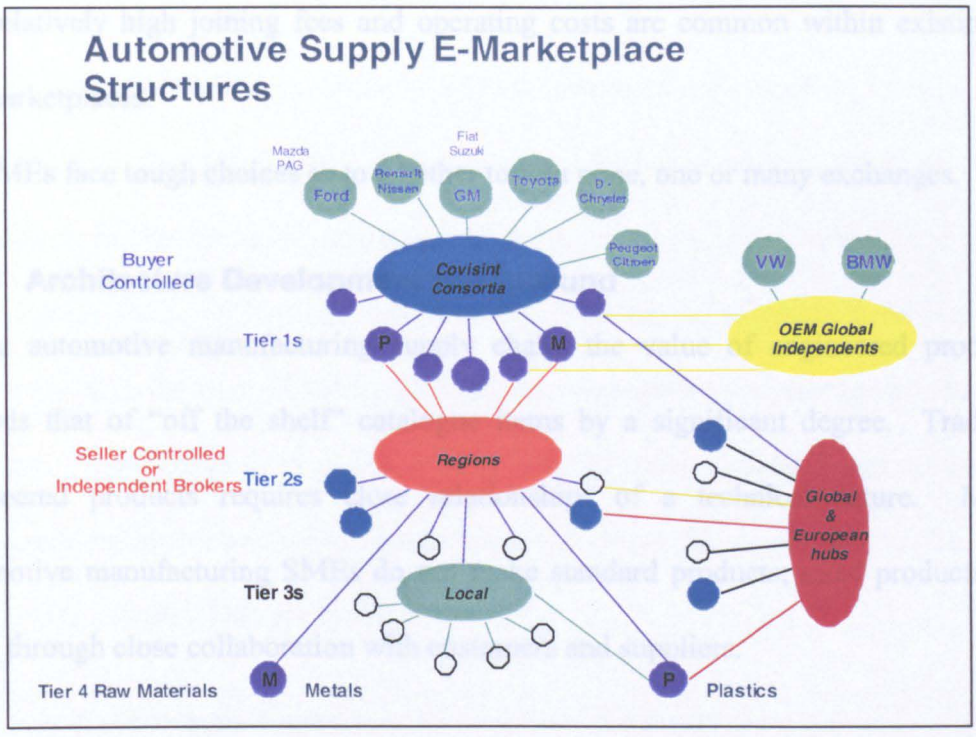

Figure 8 - Automotive e-marketplace global positioning & European hubs

Overall, the characteristics of e-marketplaces from a manufacturing SME's perspective comprises of a number of common themes:

1. It is difficult for an SME to participate in either of these types of e-marketplaces.
2. They are generally being driven by major multinationals that have dominant power and control - top driven change as EDI systems.
3. Most of them have multi technical standards and processes which demand dedicated software and technology – again as EDI systems.
4. E-marketplaces offer significant volumes of trade, market exposure and potential market opportunities for SMEs.
5. Typically, for example, the typical SME in the West Midlands region works in four industries.

6. Relatively high joining fees and operating costs are common within existing e-marketplaces.
7. SMEs face tough choices as to whether to join none, one or many exchanges.

3.2.3 Architecture Development Background

In the automotive manufacturing supply chain, the value of engineered products exceeds that of "off the shelf" catalogue items by a significant degree. Trade in engineered products requires close relationships of a technical nature. Many automotive manufacturing SMEs do not make standard products; most products are made through close collaboration with customers and suppliers.

The design, manufacture and delivery of automotive products, within the supply chain, require an ever-increasing level of knowledge, expertise and complexity. Product design needs the establishment and sustenance of rich relationships in order to facilitate Concurrent Engineering between partners and stakeholders. Collaboration costs can be substantial for SMEs, especially when they have contracts with different OEMs using different technical standards and expensive Computer Aided Engineering software tools.

Previous efforts at establishing these rich relationships electronically within supply chains have failed, due to high cost and technical expertise requirements. Electronic Data Interchange (EDI) is a good example of a supply chain collaboration technology that has failed to reach the middle and lower levels of the supply chain [22-24].

3.3 Approach

A traditional marketplace historically allows customers and suppliers to meet at a particular place and time, in order to communicate buying or selling intentions. An e-marketplace brings multiple buyers and sellers together in one central virtual place. This enables them to buy and sell at a dynamic price, which is determined in accordance with the rules of the e-marketplace, also known as an electronic exchange or portal. It facilitates buying and selling between many suppliers and customers, resulting in the power and control being dispersed within the supply chain rather than resting with a large OEM, for example.

3.3.1 E-marketplace Approach

In practice, industry-focused e-marketplaces are led by large multinationals who have ultimate power and control over their members. This leads to SMEs being bound their rules, adopting their IT systems and paying their joining and transaction fees.

As part of the EngD programme, a regional e-marketplace approach was developed which introduces new a type of e-marketplace business model. The focus is on collaboration and competences rather than products, encouraging SMEs to make different components and move into new markets.

A significant problem for manufacturing based SMEs is that many existing e-marketplace models are highly product orientated, whereas the engineering industry is very process orientated. Hence, the large number of product catalogues that exist on the World Wide Web. Engineering companies are defined by their competencies, not by their existing products. Many manufacturing SMEs provide highly customised products or 'one-off' jobs and so standard information, such as prices or stock levels,

hardly exist. In addition, existing models are biased towards the needs, resources and skills of larger companies, such as the multi-nationals at the top of the supply chain.

An example is given of a West Midlands SME in the Automotive Sector whose competence was forming (bending) wire into complex shapes for vehicle seating. It transferred its competence to making body-piercing jewellery and became a leading producer in the UK. Both types of work fundamentally use the same process of precise bending and manipulation of wire; however the profit margin in body-piercing jewellery is over 100% as opposed to 5% to 10% typically in the automotive sector [25].

This type of step change needs to be encouraged within the e-marketplace, aided by collaboration with complementary and willing partners. Competence transfer can allow SMEs to target additional markets and, combined with collaboration, allow complex engineered systems to be designed and produced rather than single component parts.

A Cisco Systems Incorporated study found that European SMEs using online activities to increase business are seeing their margins grow from 5-20% to 20-40% over a twelve-month period. This was achieved by "using the Internet extensively to form ecosystems to communicate internally and improve relationships with customers and partners", essentially internal and external collaboration. The typical Automotive SME in the West Midlands region has margins of around 5% [26]. Adopting the Internet in this way would present possible margin growth opportunities for SMEs if they can harness e-marketplaces.

3.3.2 E-Marketplace Landscape

There are many industrial e-marketplaces in existence with many business models. However fundamentally there are two main forms:

1. Horizontal e-marketplaces which offer a wide range of goods & services required by all types of businesses. This could include stationery provision or Maintenance Repair and Operations (MRO). Examples of this type of e-marketplace include SupplyOn (engineering) and steelsellers.com.
2. Vertical e-marketplaces which serve a single industry. It is buyer-based involving collaboration amongst large, often competing companies. Examples include Covisint (Automotive) and Exostar (Aerospace and Defence) both of which are supported by very large powerful multi-national OEMs such as Ford, GM, Boeing and BAE Systems.

Since the emergence of the Internet and the World Wide Web, SMEs have faced both business and technical challenges in trying to exploit its potential. A number of SME e-business adoption guides have emerged to help SMEs successfully exploit the benefits of Internet trade such as Fingar's 'Three Wave Model' [27], Michael Earl's 'Evolving the E- Business Model' [28] and Cisco Systems Inc. 'Principles of Internet Strategy' Model [29]. These usually prescribe an evolutionary approach, typically, the five proposed steps (in Cisco's model) seen in Table 2 below:

1	**Connect**	E-mail, business communication use of the Internet to build new strategies.
2	**Grow**	Website, Internet marketing, an evolution in business strategy.
3	**Trade**	E-commerce, increasing channels to market in the Internet age.
4	**Build**	E-business, reengineer your business model for the Internet economy.
5	**Evolve**	Ecosystem, The business ecosystem, a new concept for the Internet economy.

Table 2 – Cisco Systems Guide to the Principles of Internet Strategy [29]

The projects undertaken during the EngD demonstrate that, for manufacturing SMEs, this viewpoint is ill focused. In the Autocle@r project and Rover Task Force funded AutoLean III regional project, described in Submissions 3A and 3B, a significant number of Automotive SMEs in the West Midlands were exposed to new collaborative Internet and Communications Technologies. A number of SMEs were provided with funded ICT hardware. Although providing hardware is useful, the main concern of SMEs is identifying what to do regarding IT and e-business. From these projects, a number of lessons were learned in terms of what capabilities SMEs possessed and what ICT requirements they needed in order to undertake collaborative working.

Nearly all SMEs studied in these projects had achieved Step 1, most are struggling with Step 2, and a few are addressing Step 3. Many simply feel that they do not have the time, expertise or knowledge to address the issues properly.

This is compounded by cost down efficiency pressures leading to concepts such as a batch size of one. Thus profit margins for many SMEs are low, rarely rising above 10% in the automotive sector. In the industry as a whole, there is a major over capacity in car assembly manufacturing plants, with an arithmetic mean capacity utilisation of approximately 75% [30-31]. A future downturn in sales will reduce manufacturing plant utilisation further and losses may become intolerable. Automotive-based manufacturing is a key activity in the West Midlands. SMEs desire higher value business, to undertake the supply of lucrative systems rather than components or at least gain access and exposure to new business opportunities and markets.

The West Midlands region lies in the heart of the United Kingdom (UK) and has a population of some 5.3 million people [32] representing 9.5% of the country's workforce. The region is the UK's manufacturing and agricultural heartland and the hub of the national transportation network. Overall, the region generates £60.9 billion in GDP for the UK economy.

For SMEs operating in the West Midlands automotive sector, the figures in Table 3 provide a median descriptive profile. An SME is defined as a company having less than 250 employees and a turnover of less than 40 million Euros.

SME Category	Mean Average
Number of employees	23
Gross turnover (x 000)	£1,000
% business with automotive sector	42%
% with largest automotive sector customer	20%
Total number of customers	55
Significant automotive sector customers	8

Table 3 – Mean average of SMEs within the West Midlands

Source: AutoLean II Project Summary Report, Accelerate Partnership [26]

A number of Industry specific e-marketplaces have arisen to help the product development and sourcing process. Covisint and SupplyOn are prime examples in the automotive sector. However, the research from AutoLean II shows that for SMEs supplying the automotive sector, typically just under 50% of their turnover is derived from that sector. Does such a firm need to sign up to three vertical e-marketplaces, each with its own unique protocols, procedures, practices and, ultimately, costs? To participate in e-business via the many e-marketplaces that exist is not viable for SMEs with limited funds and technical capability.

The original focus of e-marketplaces was on procurement, transactions and commerce. The Internet revolution and expansion of the late 1990's has evolved through hyper growth to today's consolidation, with collaboration being a key theme. Many of the surviving e-marketplaces, such as SupplyOn and Covisint, have changed their emphasis to collaboration and online co-working. Collaboration is being recognised as the vehicle to achieve real cost savings and efficiencies.

3.3.3 E-marketplace Growth Forecasts

Estimates of the turnover in global B2B e-business for 2004 are simply staggering; according to eminent researchers Gartner Research and Forester Research, it is set to be between $2.65 trillion and $5.7 Trillion (US definition). A consensus figure taken from four sources proposes e-business projections for 2004 at a colossal $3.94 Trillion [33]. Table 4 predicts the amount of trade in manufacturing expected to flow through e-marketplaces. Given these levels and potential for new business opportunity, the number of SMEs participating in e-business activities is disappointingly but not surprisingly low. A survey reported that the number of UK Manufacturing SMEs offering online e-business capability was less than 30% [34].

B2B Growth Forecasts						
	2000	2001	2002	2003	2004	2005
AMR Research	$0.40	$0.70	$1.20	$2.40	$5.70	
Gartner, Inc.	$0.20	$0.50	$0.90	$1.80	$2.70	$3.70
Forrester Research	$0.45	$0.70	$1.15	$1.85	$2.65	
Jupiter Research	$0.30	$0.90	$1.50	$3.00	$4.70	$6.25
Consensus Forecast	$0.34	$0.70	$1.19	$2.26	$3.94	$4.98
· expressed in *trillions* of dollars						

Table 4 – B2B Growth Forecasts

Forecasts issued by Jupiter research, a research company, suggests that an increasing number of businesses will use e-marketplaces more for collaboration than for sales over the next year [35]. Specifically, the report states more than a quarter of e-marketplaces will implement features that will allow companies to facilitate collaborative online activities, including inventory monitoring and product design.

It should be acknowledged that excessive optimism and market growth predictions have fuelled the growth of e-markets and the statistics themselves. However if this research turns out to be only 10% of the predictions (although likely to be much higher) then the potential for online trade opportunity is very significant. Indeed, there are some who suggest that current projections are excessively pessimistic [33].

For example, Ford, a key player in the region, plan to switch 8-10% of its annual purchasing budget (£704m) to Internet based trading systems. Robert Bosch, a 1st Tier automotive component manufacturer in one of its German divisions, is moving 80% of procurement online by the end of 2004 [36]. It is important not underestimate how fast and pervasive the movement of B2B transactions online may become. Companies cannot afford not to participate in or ignore the potential of e-marketplaces. It is imperative that SMEs join such e-marketplaces to tap into the increasing transactions flows.

If the majority of the SMEs in a region do not or cannot participate, then the region faces becoming an electronic backwater. An analogy used to illustrate the effect is "it's like having a motorway running through the region, but having no junctions to access it."

3.4 Solution and Validation

A viable solution therefore would be the provision of an industry independent e-marketplace to facilitate the communication and collaboration between the OEM and SME suppliers to enable the sharing of information and knowledge. The e-marketplace would consider the whole cycle of the work processes, from identifying

and finding new suppliers and winning new orders, through to collaborative product development and to providing production order information. Close relationships could be formed allowing complex design, prototyping and production parts to be produced with complementary suppliers.

3.4.1 Introduction

In November 2002 the author co-authored with Dr. Jay Bal (University of Warwick) a paper for the IEE Manufacturing Engineer journal [37]. The paper described the reasoning and architecture behind a new electronic marketplace focusing on supporting manufacturing based SMEs. The architecture leverages a number of elements to enhance the prospects for manufacturing SMEs and the region in which they exist.

1. It focuses on the SME's potential, not on their current practice as is the case with many other e-marketplace models.
2. It exploits regional identity, expertise and loyalty to help set up new collaborative relationships. This has been attempted manually by organisations such as the Chambers of Commerce, but not electronically before.
3. It recognises and is based on the fact that SMEs may be willing to adopt new processes and methods of working for new high value projects, but will in general want to continue traditional ways of working for most existing business.
4. Manufacturing SMEs have little money, desire or motivation to invest in new IT systems.
5. A way of addressing the cost down pressures of OEMs wanting to source from low cost countries needs to be derived.

3.4.2 Regional e-marketplace Model

As a direct result of the research and work carried out during the EngD, a proposal for funding was put forward to the Government Office for West Midlands (GOWM). A total of £3.6million was secured for a regional e-marketplace in the West Midlands area – the West Midlands Collaborative Commerce Marketplace (WMCCM) four year project is funded through the EU European Regional Development Fund (ERDF) programme which acts as an instrument to readdress the economic imbalances within less prosperous regions in the European Union. Funding was awarded by GOWM for a number of reasons, including a recognition that WMCCM offered manufacturing SMEs the opportunity to access new markets through e-trade.

There have been various attempts at developing e-marketplaces in other regions in the European Union. Examples of these include the Schweitzer Marketplatz Online (www.smo.ch), in Switzerland and the Lake Constance Marketplace (www.mbo.de), in Germany. Although both have had varying levels of success, they have been directed towards the Business to Consumer market. The WMCCM model is unique because it is aimed firmly at the regional Business-to-Business engineering related market, and is designed to encourage collaboration to address new opportunities. Many of the existing approaches described above focus on e-enabling existing ways of working. The WMCCM marketplace provides a new partnership search capability embedded in a process of:

1. Identifying new opportunities
2. Finding partners to help address these opportunities, and

3. Providing a collaborative working environment to help expedite the addressing of new opportunities.

WMCCM applies the ideas and concepts to the needs of SMEs in the core West Midlands region and provides an e-collaborative marketplace for the West Midlands geographic area. Currently the e-marketplace is free, in terms of joining costs and operation costs, to all SMEs within the West Midlands region. The rationale of the funding model is that the e-marketplace should be paid for out of taxes, in the same manner as other regional 'transportation' infrastructures such as local roads and railways. Whereas road infrastructure is physical and connects to the national and international road systems, the e-marketplace is virtual and connects to the Internet information super highway.

The collaborative marketplace will allow SMEs to participate in regional, national and international e-trade under better conditions. The key elements of the regional e-marketplace and subsequently in WMCCM are:

- Takes care of IT implementation and complexity for its members – acts as a clearinghouse between other e-marketplaces undertaking data translation via XML.
- Competence Profiling and Search capability - this capability is based around understanding the processes and skills of individual Manufacturing SMEs (their competence). Before the SME's can be exposed to new markets and opportunities, a competence profile questionnaire will need to be completed. This gathers information such as key processes and skills, quality standards and key

markets. It can then be searched for appropriate skills and competencies to form Virtual Organisations in order to respond to enquiries or tenders. Bidding for tenders, for example, is based upon capability of their competences, regardless of whether they have done the type of work before.

- Virtual Teaming Collaboration Capability - The system allows the creation of secure project spaces, using SSL (Secure Sockets Layer), allowing collaboration with other members, regardless of industry. It provides project management tools and document versioning control functionality to enable this collaboration. This forms part of the Collaborative Toolset, described in Chapter 5.
- Marketplace Capability – Full tenders capability through the ability to generate and respond to Request for Information (RFI) and Request for Quotation (RFQ). It links to a number of external relevant e-marketplaces and also provides a lead service for members which can be filtered to match the requirements of the SME.
- Purchasing Aggregation Capability - Provide links to the catalogues of approved suppliers and service providers to the WMCCM. These allow SMEs registered on the e-marketplace to directly order goods and services. Initially this is focused at the procurement of non-direct materials, rather than core materials and services which are more sensitive to businesses needs.
- Clustering Capability – related members with common interests can gather together electronically and form a virtual space with a common look, feel and set of information services. This can be based on their location, expertise or market. For example currently on WMCCM there are clusters for an Information Technology association and a Coventry Industrial Estate.
- Auction and Bazaar Capability- online auction with the facility to create public and private auctions. Simple private auctions, with associated management tools,

can be created in a password protected area for preferred suppliers to view and bid. In addition, the Bazaar facility is virtual place where surplus goods and requirements can be posted and traded. For example, excess or slow moving stock or obsolete machinery can be advertised to other WMCCM members.

- Catalogue Capability – Since most SMEs do not make or sell standard components, an online catalogue can be created to demonstrate capability. This effectively acts as a process catalogue "showcase".

The schematic model of WMCCM can be seen in Figure 9.

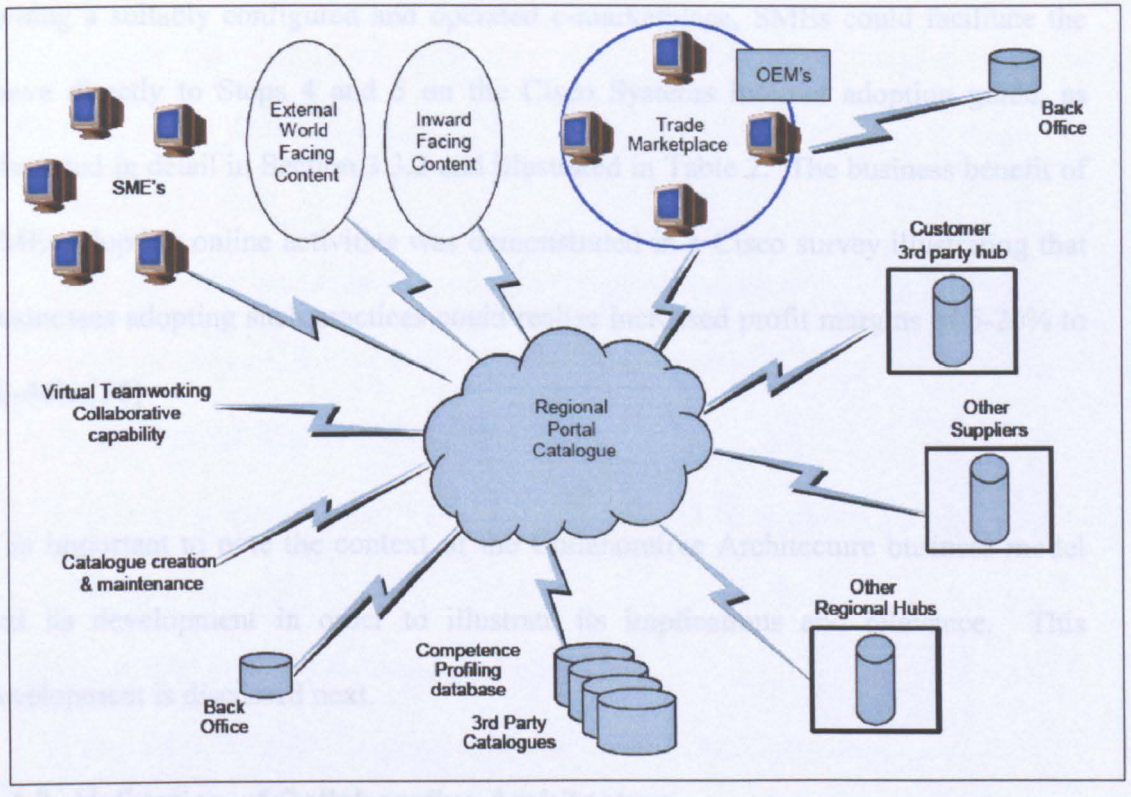

Figure 9 – Regional e-Marketplace Infrastructure Model

WMCCM is an innovative e-marketplace model, which is complementary to existing models. The regional e-marketplace model circumvents the traditional route to e-

business and provides a natural stepping-stone into e-business and online collaborative working. The e-marketplace acts as a clearinghouse or intermediary with neutral power and control. Thus, SMEs can participate on equal terms regardless of their physical and financial size; this is the opposite of industry focused e-marketplaces such as Covisint and Exostar.

In order to participate, SMEs need only a PC, an Internet Browser and Internet access, in order to access the regional, national and international trade highways. A primary business benefit and incentive for SMEs is the possibility of gaining new business, which would otherwise pass by on the Internet superhighway without stopping. By joining a suitably configured and operated e-marketplace, SMEs could facilitate the move directly to Steps 4 and 5 on the Cisco Systems Internet adoption guide, as discussed in detail in Section 3.3.2 and illustrated in Table 2. The business benefit of SMEs adopting online activities was demonstrated in a Cisco survey illustrating that businesses adopting such practices could realise increased profit margins of 5-20% to 20-40%.[38]

It is important to note the context of the Collaborative Architecture business model and its development in order to illustrate its implications and relevance. This development is discussed next.

3.4.3 Validation of Collaborative Architecture

Full validation of the proposed architecture can only be conducted over a longer period of time than available within this research project. However, validation has been undertaken through expert and user opinion, feedback, and direct testing of some

of the key individual components of the system with SMEs. These and other issues are discussed in the subsequent sections.

3.4.3.1 User Validation through Workshops

During the development of WMCCM, both the technical and business models were evaluated through a number of SME user workshops. The participants were chosen to give a balanced perspective on the needs, requirements and relevancy of the regional e-marketplace model. They included an IT SME (5 employees, high IT usage), a Presswork SME (200 employees, low IT usage) and an electronic systems SME (30 employees, medium IT usage). A listing of the participants is given in Appendix A.

3.4.3.2 Expert Validation

Validation of the model has been given by a number of regional bodies and institutions during the development of WMCCM. A full listing is shown in Appendix A; briefly they include:

- Advantage West Midlands (Regional Development Agency)
- Accelerate (regional initiative for Automotive Industry)
- WMita (West Midlands IT Association)
- Government Office for the West Midlands (WMCCM financers through the EU ERDF programme)
- The National Business to Business Centre
- Plastics West Midlands (regional initiative for the plastics industry)
- Bayton Road Industrial Estate (largest industrial estate in the West Midlands comprising over 200 manufacturing based firms)
- First Index (e-marketplace for custom manufactured parts)
- Advanced Engineering Cluster (regional engineering initiative)

- 2WM (West Midlands online gateway)

3.4.3.3 Proven Set of Components

The e-marketplace model used for WMCCM uses a suite of components developed, tested and proven to work effectively on other projects with manufacturing based SMEs. For example, the Low Cost Virtual Teaming toolset has been used during the Autocle@r and TASC Net projects (see submission 3B for details.)

3.4.3.4 Time

WMCCM went live in January 2004. An indication of whether project performance objectives have been met will not be possible for at least two years. However, since the project is funded by local government there are comprehensive measures in place to ensure the project runs to plan. Early indications are very positive and show after three months that:

- Over 1,500 companies registered
- 180 SMEs had started to use collaboration spaces and were competence profiled
- Approximately 1,800 tenders (RFIs / RFQs) received per month
- Approximately 25 online Virtual Teaming collaboration spaces created for SMEs
- 3,000 pages requested per day
- Clusters created for partner associations or interest groups

An incremental roll out of functionality is being taken during the initial stages so that SME members can gradually build up familiarity and confidence.

3.5 Collaborative Architecture Conclusions

To date there is no accepted B2B e-marketplace model that gives investors confidence in their long-term financial viability as independent businesses. A regional model introduces new financing options. It is also closer to the grass roots, tapping into regional loyalties and local social dynamics that are difficult to reach for the multinational B2B operators. For a 25 employee plastic injection moulder, located in a large industrial region, membership in a single regional e-marketplace with gateway links to new trade opportunities and access to potential collaborative partners to strengthen core competence will be a very strong proposition.

SMEs serve many different markets so joining one e-marketplace, either one vertical or horizontal marketplace, will not supply all their business needs. SMEs cannot afford to join because of costs alone but the potential is such that they cannot afford not to join. The Collaborative Architecture has been formed by existing e-marketplace models and meeting the needs of manufacturing SMEs.

A regional e-marketplace model can quickly help SMEs change from doing little or no e-business to running a fully integrated e-business. In order to achieve this, the e-marketplace, must focus on engineered goods. Rather than choosing standard products from e-catalogues, it must focus on the manufacturing SME's ability to make what the customer wants. Competence profiling of SME members will allow a standardised analysis of process capability to be taken and showcased. With ever-increasing globalisation, it could be argued that without such a facility and the access to markets it can provide, many engineering suppliers face a bleak future.

The next level, which supports the Collaborative Architecture, is Collaborative Processes and sets out, through a Virtual Teaming approach, the tools and techniques that encourage successful collaboration. This is discussed in the next chapter.

CHAPTER FOUR

COLLABORATIVE PROCESSES

4 Collaborative Processes

The previous chapter charts the background, development and status of the Collaborative Architecture for manufacturing based SMEs. This chapter defines the processes necessary to enable effective collaboration. The Collaborative Process consists of a methodology for implementing collaborative Virtual Teaming within manufacturing based SMEs. There has been much research on such processes, but most of this relates to collaboration among executives. The analysis undertaken evaluates this research in the context of engineering collaboration. This chapter will give a brief overview and provide the background to its formation, development, current status and intended future work.

4.1 Introduction

The data set investigated was focused on the theme of collaboration within manufacturing related SMEs and in particular those serving the automotive component supply chain. This work is derived and based upon experience and knowledge gained from the Autocle@r and TASC Net projects and the implementation of Collaborative Process and Virtual Teaming within approximately thirty SMEs and an extensive review of the literature

The literature for Virtual Teaming collaboration is assessed in Submission Two and the "Autocle@r" project is described in Submission Three B. A Low Cost Virtual Teaming (LC VT) collaborative environment suited to small manufacturing based SMEs was developed and deployed within thirty automotive SMEs in the West Midlands. This approach allows SMEs to exercise their knowledge with external project partners irrespective of their geographical locations. A system based on

Microsoft NetMeeting (www.microsoft.com/netmeeting) and MSN Communities (www.communities.msn.com) was configured and provided to twenty SMEs. Such a low cost system (in terms of capital and running costs) had not been applied before for SME collaboration.

4.2 Virtual Teaming Approach

Organisations are continuously under pressure to gain competitive advantage. There are many factors encouraging the introduction of Virtual Teams including shortened project times, lower costs, improved staff safety, and the access to a greater range of knowledge. For example, Virtual Teams enabled the development of "a radically new product" in a reduced project time and travel costs on a complex Boeing-Rocketdyne project, using collaborative technology [39]. In a further example, the proceeding months after the 911 terrorist attacks on New York, over sixty international conferences were cancelled due to safety concerns, a number of which replaced by online conferences [40].

The literature review undertaken studied collaboration practice through Virtual Teaming and included the review of seven key texts in order to develop the collaborative Virtual Teaming process framework – see Submission Two. This sought to establish any gaps between literature reviewed and the needs of the manufacturing based SMEs. The key Virtual Team literatures reviewed were:

- Lipnack, J. and Stamps, J. *Virtual Teams: People Working Across Boundaries with Technology.* [7]

- Kostner, J. *Bionic e-Teamwork: How to Build Collaborative Virtual Teams at Hyper Speed.* [8]
- Duarte, D. and Snyder, N. *Mastering Virtual Teams.* [15]
- Fisher, K. and Fisher, M. *The Distributed Mind.* [16]
- Haywood, M. *Managing Virtual Teams: Practical Techniques for High-Technology Project Managers.* [17]
- Henry, J. and Hartzler, M. *Tools for Virtual Teams.* [41]
- Lipnack, J. and Stamps, J. *Virtual Teams: Reaching Across Space, Time and Organisations with Technology.* [42]

Through a literature and technology review, the three main components for the formation of Virtual Teams; People, Process and Technology Enablers, within small manufacturing based companies were analysed and key guidelines derived.

The Virtual Team literature highlights, as indicated in the following, six common Virtual Team principles.

1. Having clear goals and objectives is a critically important feature of Virtual Teaming. Although goals are important, good goals are not sufficient unless they are used as a tool for self-regulation and assessment [7, 16, 17, 41].

2. Managers of Virtual Teams will have to develop communication skills to prevent members feeling isolated from the organisation. Communication within Virtual Teams is compromised by technical and cultural factors [7, 15].

3. The role of the Virtual Team leader and the functions of the leadership role have been given considerable attention by many of the authors reviewed. The competencies needed to be an effective team leader or member of a Virtual Team are assessed [7, 15, 16, 17].

4. Shared Values, Team, and Organisational Process can inspire the Virtual Team and is a fundamental principle of the model [15, 16, 17, 41].

5. Due to the unique nature of Virtual Teams, there needs to be a structured guide to help managers redesign their performance measures and reward system specifically for members [17].

6. Finally, without Trust, close relationships will be difficult to build and the long-term success of the Virtual Team compromised [7, 41].

The literature review revealed that most published work has focused its attention on Virtual Teams for the general business environment, concentrating on the work of executives rather than engineers. The use of Virtual Teams within engineering environments differs from that of executives due to being more visually based [43] and the amount and depth of data being higher[44]. Online engineering collaboration can involve exchange and manipulation of sensitive information and data via the Internet. Therefore, security is an important issue of concern. The viewing and manipulation of design data between remote team members is a fundamental part of the concurrent engineering design process. This work addresses an important gap in

the literature: how Virtual Teaming and the requirements of engineering collaboration among SMEs can be implemented successfully.

The results from the Virtual Teaming literature, and the subsequent gap is the focus of this work. It provides a framework of Virtual Teaming processes, which consider the existing VT literature and its review / gaps, present modifications to meet the needs of manufacturing based SMEs, and develops and evaluates guidelines on a number of practical projects.

The technologies available to enable Virtual Teams are described in the portfolio (see Submissions Two, Three A and Three B). Video Conferencing, especially for visually dominant activities such as engineering design, provides the richest experience for users. However, research has identified that an electronic whiteboard and audio system were the most important tools for Virtual Teaming [13]. The importance of the appropriate bandwidth connectivity is also highlighted.

4.3 Virtual Teaming Process

Experience with implementing Information Technology successfully in a number of manufacturing based organisations during the research has shown that it needs to be considered as a business initiative, not a technology IT initiative. Of the twenty steps in the Virtual Team methodology (see Figure 10), only one is about technology and hence its supports the key principle that success in implementing Virtual Teamworking is more about processes and people, than about the technology.

The methodology derived focused solely on the needs of engineering collaboration, and thus is more closely suited to the needs of manufacturing based businesses and is subsequently devised to meet the needs and constraints of SMEs. This adaptation of Virtual Teams practices to engineering and manufacturing based SMEs is novel, since prior work concerns collaboration among executives and / or large organisations.

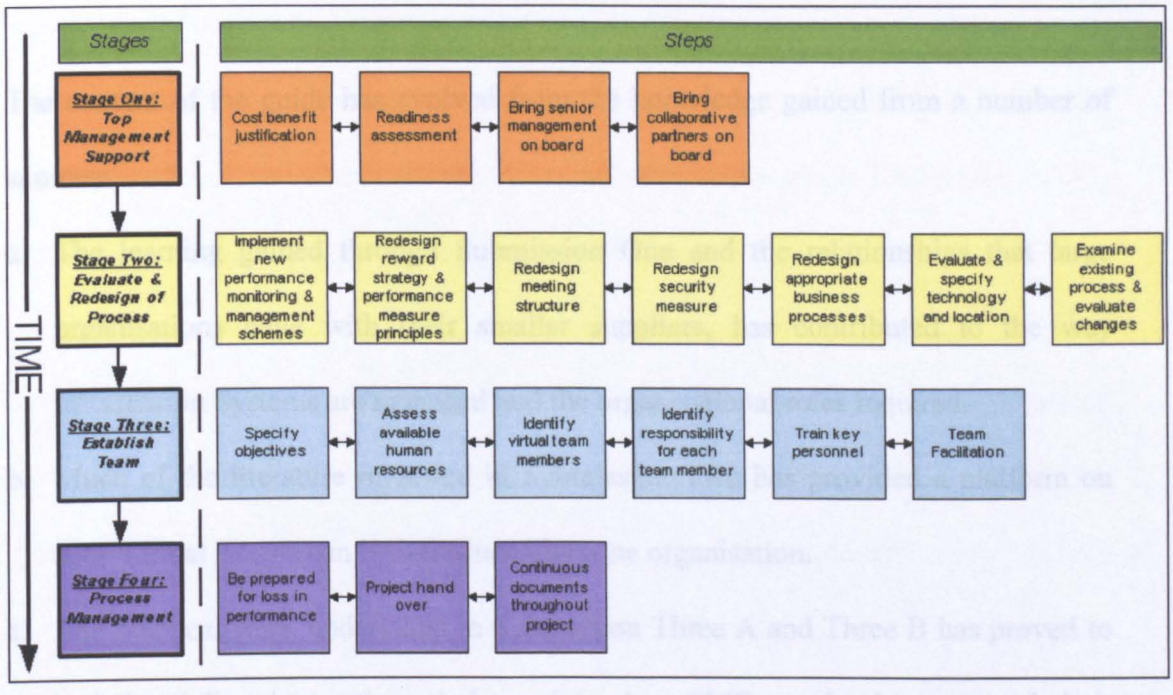

Figure 10 – Virtual Teaming Implementation Process

The Process component of Collaborative Architecture implementation has become more critical since the original research for Submission Four was completed.

The effective deployment of any new process within an organisation can be fraught with difficulties. Implementing Information Technology (IT) based processes within a small company with limited IT knowledge and experience compounds these difficulties even further.

A particular difficulty with the application of Virtual Teaming within the SME environment was the constraint of low bandwidth and consequently most of the work is centred around providing process based 'work-a-rounds'. Thus, the guide developed (Submission Four) presents a set of guidelines that will provide help in adopting Low Cost Virtual Teaming (LC VT) systems within SMEs which in turn supports the overall Collaborative Architecture.

The content of the guide has evolved from the knowledge gained from a number of sources:

a. The learning gained through Submission One and the relationships that large organisations have with their smaller suppliers, has contributed to the way Information Systems are managed and the organisational roles required.
b. Much of the literature reviewed in Submission Two has provided a platform on how Virtual Teams can be introduced into the organisation.
c. The practical work undertaken in Submission Three A and Three B has proved to be industrially relevant through determining how SMEs need to be supported, their issues and constraints.

The guide is structured in three main parts:

Part One - A comprehensive set of general techniques and progressive instructions, dependent on whether the user is a beginner/low-level, intermediate/medium-level or expert/high-level. These consider preparatory issues such as testing the system and setting up the lighting, audio and video.

Part Two - A number of tools and techniques are introduced that can assist in continually improving the Virtual Team meeting process. This is realized through determining the team roles, creating effective meeting agendas, developing meeting logistics, evaluating the meeting structure and undertaking assessments of the whole process.

Part Three - Presents how the technology is installed, set up and the system features used. Setting up the technology used within the low cost system can be fraught with numerous pitfalls and complications. By following these points SMEs can quickly and easily get the LC VT system in operation with minimal prior technical knowledge.

The result of developing these guidelines was that it formed the basis of the training package for Autocle@r, and the TASC Net projects. SMEs were presented with this during the induction process and it was utilised in over thirty automotive supply chain SMEs.

4.4 VT Implementation Projects

The set of Virtual Teaming guidelines were evaluated on the TASC Net project described here.

4.4.1 Frederick Woolley Ltd and the TASC Network

One of the outputs of the Autocle@r project was the undertaking of further work for an SME who participated in the project. This was Frederick Woolley Limited (FWL) and their associated community network TASC Net.

FWL is an SME based in the Birmingham area, employing approximately 200 people. The company, established in 1935, has two main production processes: presswork and welded assemblies, and cable harnesses. It is a second tier supplier of pressed metal parts and cable harness assemblies to the automotive industry. The main customers of FWL are 1st tier suppliers Denso and TRW Automotive who supply direct to OEM customers such as Toyota, Honda, Nissan, BMW, Volkswagen, and Volvo.

FWL are considered by many to be a leading SME within the West Midlands Automotive supply chain and this has been recognised through a number of accolades and awards, including:

- The Kelly's SME Award for Excellence in Purchasing and Supply (2000)
- The DTI 'Inside UK Enterprise' Initiative Award for Best SME (2000)

4.4.2 Validation of Collaborative Processes

A community trial was conducted in the TASC Net (The Automotive Supply Chain network) project during the EngD.

FWL worked closely with various other SMEs possessing complementary skills and competences, within the West Midlands area. These SMEs set up 'The Automotive Supply Chain network' (TASC) in 1997 with the aim of gaining synergies through the sharing of knowledge, the 'pooling' of resources and shared learning. These cluster activities were undertaken in addition to their existing inter-business relationships.

Porter defines a cluster as a "geographic concentration of interconnected companies, specialised suppliers, service providers, firms in related industries and associated institutions in particular fields that compete but also cooperate" [45]. This fully describes the TASC Network since they are geographically located within the West Midlands, connected by monthly physical meetings with each company in competing business sectors and industries.

The TASC Network was an existing closed business community, which physically met up once a month to discuss common issues and give support. To facilitate this further, an asynchronous online community was developed and implemented using a low cost approach. The community was set up using Microsoft's MSN Communities (see Figure 11). It had a number of shared features such as a Calendar, bulletin board and various file storage areas. However its structure and configuration was deliberately left bare to assess if 'organic' growth of the community occurred. However the community only started to function once the Operations and Human Resources Directors at FWL acted as a change champion and drove participation in the network.

A cluster is important because, through a network of interconnected companies such as TASC Net, it can create additional and complementary capability. In particular, TASC Net wanted to improve knowledge sharing, resource sharing and group learning.

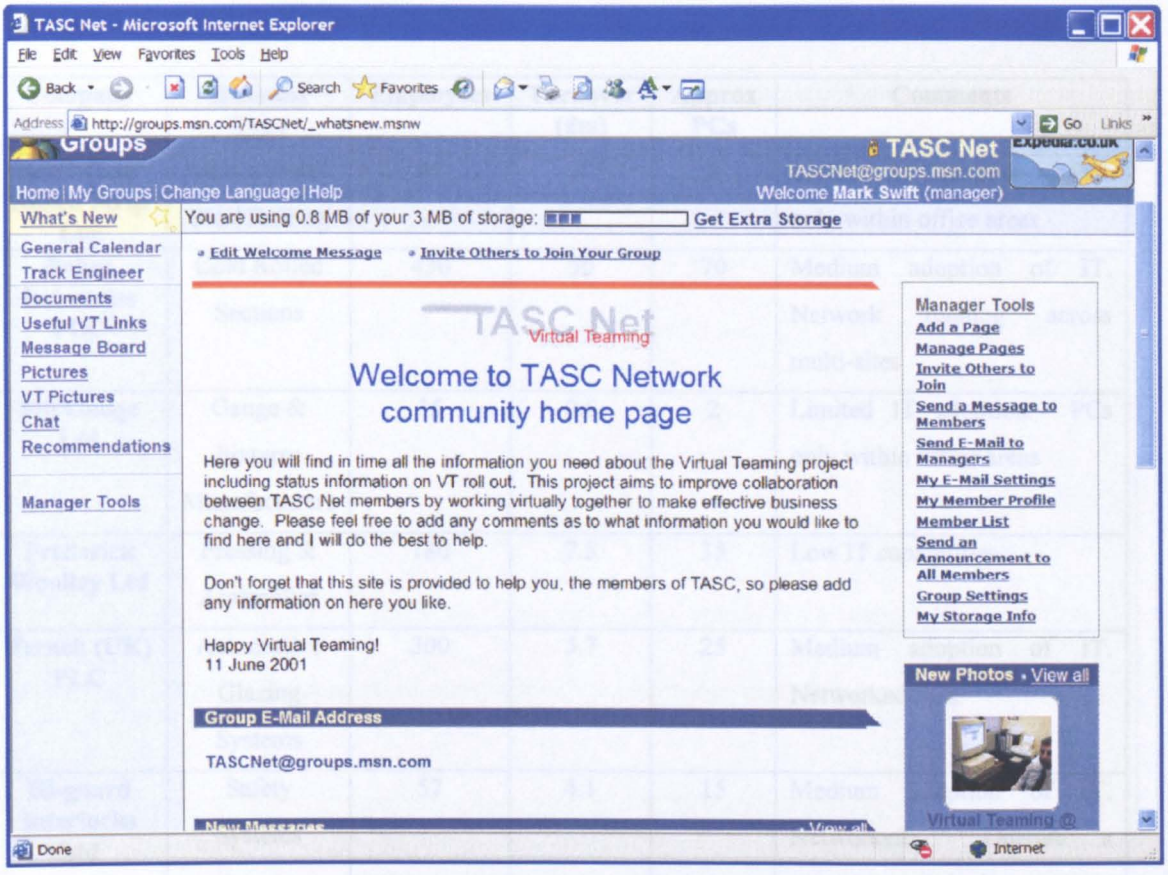

Figure 11 – TASC Net Home Page

The provision of Virtual Teaming within the network facilitated quick and easy online discussions, the sharing of information and allowed issues arising during product development to be resolved. This project presented a challenge since the structure and characteristics of companies in the cluster varied considerably in terms of turnover, number of employees and level of IT experience. A brief comparison of the companies within the TASC Network can be seen in Table 5.

Company	Business Type	Employees	Turnover (£m)	Approx PCs	Comments
ABC Cold Rolled Strip Ltd	Low Carbon Steel Rolling	48	4	3	Limited IT adoption. PCs only within office areas
Baker Industries PLC	Cold Rolled Sections	430	50	70	Medium adoption of IT. Network running across multi-sites
Flit Gauge Ltd	Gauge & Fixtures Manufacturers	15	0.6	2	Limited IT adoption. PCs only within office areas
Frederick Woolley Ltd	Pressing & Assemblies	180	7.5	35	Low IT capabilities
French (UK) PLC	Automotive Glazing Systems	300	5.7	25	Medium adoption of IT. Networked PCs
Hi-guard Interlocks Ltd	Safety Systems	57	4.1	15	Medium adoption of IT. Networked. Operate a ecommerce web site
Jones Load Ltd	Load Monitoring Systems	12	0.4	5	High usage of IT for software development but limited elsewhere
Market Engineering Ltd	Pressing & Assemblies	65	3.2	4	PCs only within offices
Popular Press Tools Ltd	Press Tools	30	1.5	4	Use PCs for CAD and office automation
Tool-Man Ltd	Tool Maker	12	0.5	1	Very limited IT exposure. 1 PC only within office area

Table 5 – Characteristics of Companies within TASC Network

Note: Apart from FWL who have expressed permission, the correct names have been replaced to ensure company confidentiality.

The engagement consisted of:

- Pre visit – the collection of information and preparation of software and hardware.
- Visit one – Installation, configuration, testing and training of the SME.
- Post visit – Support for the SME through phone, email and Instant Messaging.
- Visit two –approximately six weeks later, to ensure that they are realising their objectives, resolve any technical and operational issues, provide advice and further support where necessary.

A selection of Low Cost Virtual Teaming worksheets were available to assist the quick adoption of the new team working protocols needed for successful meetings, and to aid future continuous improvement. These included (presented in Appendix B):

- Low cost Virtual Teaming meeting agenda
- Record of meeting profile
- Meeting method structure
- Technical assessment
- Meeting structure summary

An example of the benefit realised through the TASC Net community follows. FWL had three CAD (Computer Aided Design) designers with uneven workloads that resulted in periods of low work activity. They were an expensive but important resource to the organisation. During periods when there was not enough work for the three designers they would be engaged in lower value activities such as administration and general office duties.

With the TASC Net community, the designers' spare capacity was made available through the virtual cluster and could be booked using a simple online calendar facility in the community. Members who needed additional design capacity within the cluster could log onto the access controlled web site and make a booking on a shared calendar – see Figure 12.

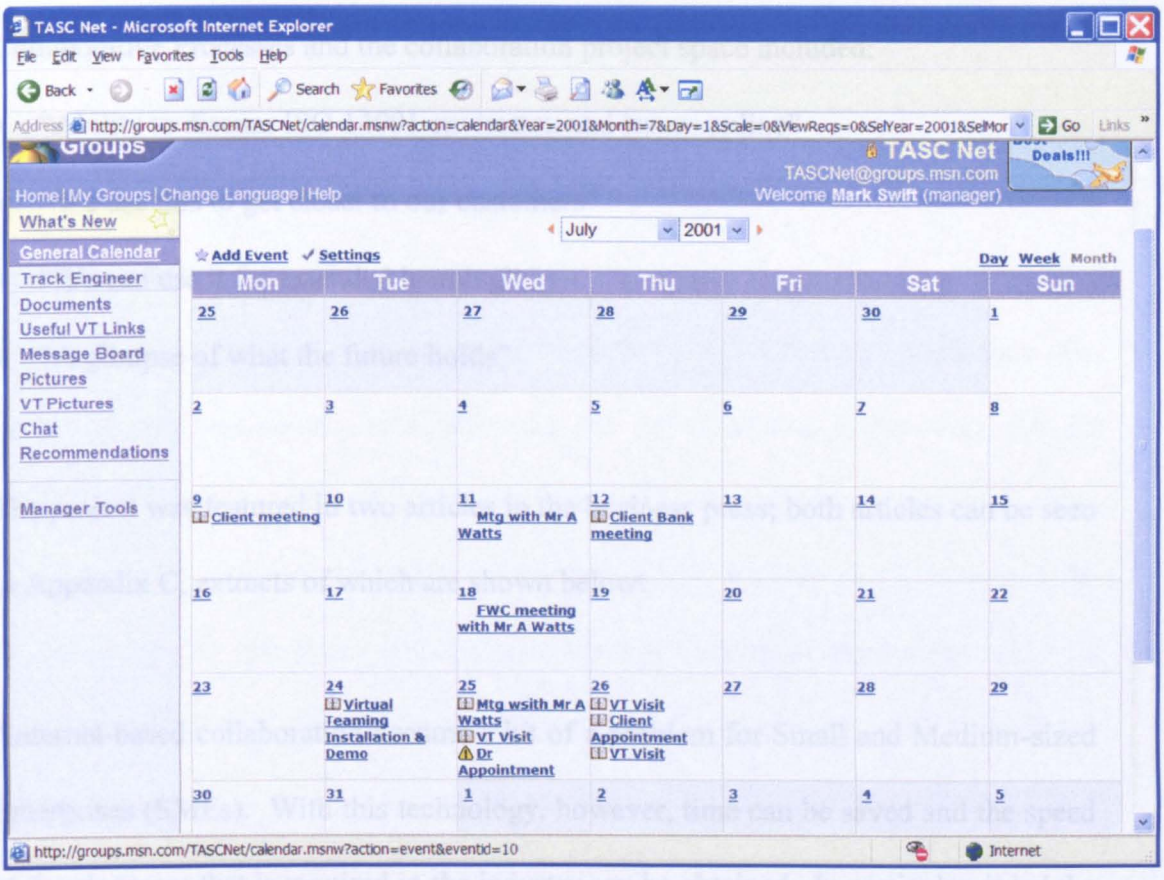

Figure 12 – TASC Net Shared Calendar Facility

The designers then could visit the member company, talk through the job requirements face to face before commencing work back at their own site. Once the work had started, updates could be given back to the partner company using the LC VT system, allowing the CAD designs to be viewed in real time by both parties through the shared program facility.

This is one example where the organisation of work tasks, through the use of Virtual Teaming methods, can enable the formation of virtual organisations for common benefits.

4.5 Feedback on the Collaborative Process

Positive feedback received by members of the TASC Network whilst using the Collaborative Processes and the collaboration project space included:

- "Ability to discuss ISO 14001 environmental issues online"
- "We use this to get closer to our customers"
- "We can use it for extended learning"
- "A glimpse of what the future holds"

The project was featured in two articles in the business press; both articles can be seen in Appendix C, extracts of which are shown below:

"Internet-based collaboration became a bit of a problem for Small and Medium-sized Enterprises (SMEs). With this technology, however, time can be saved and the speed of development that is required in the industry can be obtained. In particular, it led the Birmingham automotive supplier Frederick Woolley Ltd (FWL) online doing real collaborative commerce, including video conferencing and all the rest of it very quickly. You're not faced with budgets of millions to do this." **Source: Manufacturing Computer Solutions, Volume 7, Issue 7, 2001 [46].**

"Today engineers could be holding components up to the camera, looked at drawings and quotations – while working on the design simultaneously. We can put up a

whiteboard and alter drawings on it. A toolmaker can send in a component's digital photograph and we can draw on the component on screen together and talk simultaneously. Considering that the company has only been practising the 'e' philosophy for some eight months it has made remarkable progress." **Source: e-Manufacturing West Midlands Report, Advantage West Midlands, July 2001 [47].**

4.6 Conclusions

The Virtual Teaming systems received a mixed response. Some companies were willing to pay to expand the system (approximately £150/client) whereas others found great difficulty in using it. One example of where the LC VT system streamlined the design process was when a toolmaker was able to collaborate in real time with its second tier customer, without a time consuming visit, freeing up an engineers' time, and the tooling being completed in a shorter period. Another SME integrated the system within its web-based Collaborative Product Commerce procedures and now uses it as part of its New Product Introduction Process with OEMs such as Audi AG and MG Rover.

Feedback given by the members of the TASC Net community, claimed that the Collaborative Processes enabled members to achieve [48]:

- Remote CAD viewing and rapid prototyping during product development.
- Facilities dynamic project resource planning.
- Rapid access communication.
- Continued 'peer group learning' between members.

- Realisation of potential of the remote collaboration now and for the future.

Experience from the Autocle@r and the TASC Net projects suggests that synchronous collaboration is still beyond most companies and it may be better if they started with asynchronous capability.

4.7 Summary

This chapter has looked at the people, process and technology aspects that need to be considered in order to introduce and use (implement) the Low Cost Virtual Teaming system into the organisation. There are numerous guidelines contained in Submission Four that can be used for this purpose. However, these should not be considered as the panacea to all aspects of the implementation. Having the right management commitment, user involvement, the allocation of a change agent and realistic project expectations are just some of the supplementary considerations.

The chapter has illustrated the progress the author has made during the research of collaboration tools and methods for SMEs. This research has provided a Low Cost Virtual Teaming system for small companies and has described its implementation and developed a guide for its use. The conclusions of this work are as follows:

- Virtual Teams are a unique integration of process and technology that supports high levels of collaboration, permitting firms to co-ordinate, collaborate and teamwork with geographically dispersed partners, suppliers and customers regardless of location, space and time.

- Collaborative processes addresses the gaps in current Virtual Teaming literature regarding lack of manufacturing based engineering or small business consideration.
- Implementing collaborative technology and practices is a business initiative and more about people and process rather than technology. There are twenty steps in the Virtual Team implementation process, only one of which is specifically about technology.
- Top-level support is a pre-requisite enriched through meticulous planning.
- Synchronous collaboration is still beyond most companies; they should start with asynchronous capability. WMCCM primarily uses asynchronous tools for this reason.
- Collaborative working facilitates more frequent, shorter meetings which promote quicker problem resolution time.
- New Collaborative Virtual Teaming protocols need to be understood and communicated before an online meeting can start in order to set the ground rules. For example, participants in face to face meeting start by shaking hands, asking questions to "break the ice" or perhaps offer a coffee. No such widely accepted protocol exists for electronic meetings.
- Companies will not change existing business practice in existing relationships for electronic collaboration. It is better to focus on new venture opportunities, make changes and work differently from the start.

In this chapter the focus has been mainly on the human and process factors that drive effective collaboration. Though technology has been discussed in this context, a full

evaluation of the available technology has not been conducted. This evaluation is described in the next chapter.

CHAPTER FIVE

COLLABORATIVE TOOLSET

5 Collaborative Toolset

In previous chapters, a framework and a set of processes for effective collaboration have been described. This chapter identifies suitable technology for collaboration among manufacturing based SMEs and gives an overview of the technology and its development. It comprises of a range of asynchronous communication tools supported by the Low Cost Virtual Teaming synchronous communication tool.

5.1 Introduction and Drivers

Competition is driving companies to adopt online collaborative work systems to help support information and knowledge exchange with customers, partners and suppliers. For major multinational companies there are many collaborative technology options.

However, many SMEs have limited financial resources and little ICT technical expertise. This makes it difficult for them to use technology to share information with their immediate partners. Effective communication between multi-suppliers is critical in order to develop sophisticated product systems requiring specialist competencies.

In order to enhance effective collaboration within the regional e-marketplace, experience has been drawn from the "Autocle@r" project and latterly TASC Net. Taking a Virtual Teaming approach, a Low Cost Virtual Teaming (LC VT) collaborative environment was developed and deployed within thirty automotive component manufacturing based SMEs within the West Midlands region. The regional e-marketplace model supports asynchronous technology.

Requirements identified from the SME interviews and Virtual Teaming literature included:

1. To reduce cost and reduce project times through online collaboration.
2. To reflect the benefits of normal face-to-face meetings as closely as possible linked with the advantages of on-line conferencing.
3. To provide a low cost solution.
4. To operate within the SME's technical constraints of skills, hardware and infrastructure.

These objectives govern the technology requirements and the path of the technology review and development.

5.2 Regional e-marketplace Collaborative Toolset

The regional e-marketplace contains a comprehensive set of collaborative features. These were developed from experience gained in the Autocle@r and TASC Net projects and the literature review.

To become a member of the marketplace, two prerequisite steps are undertaken:

- Competence profile capture and refinement – to determine requirements and gather a detailed and relatively unbiased summary of the member capability.
- Training in the basic operation of the regional e-marketplace – to ensure that the understanding and benefit can be realised.

In addition to the mandatory steps, additional activities can be carried out with the SMEs, which are usually taken from a predefined number of standard options. The e-marketplace contains two types of "system modules", the first being inward facing for use by the web administrators only, such as a Management Information System. The second type is outward facing, configured by e-marketplace members, and generate externally facing content. The needs and requirements of each SME are assessed through the Competence Profile Questionnaire – a sample is shown in Appendix D. This leads to a recommendation and agreement of a number of further optional activities. These are completed in conjunction with the SME and full training given on the additional parts / modules.

Table 6 outlines a selection of standard and additional WMCCM activities and the respective regional e-marketplace modules used.

Activity	e-marketplace Modules																		
	Announcements	**Auction**	**Bazaar**	**Catalogue**	**Competence Profile**	**Contacts**	**Discussions**	**Documents**	**Email members**	**Events**	**Hierarchical Links**	**HTML**	**Links**	**Newsfeeds**	**Tasks**	**Tenders**	**Tender Subscription**	**Site Search**	**LC Virtual Teaming**	**XML / XSL (advanced)**
Competence Profiling (S)					S							A	A				A			
Create Project or Customer Space (Extranet)	A	A	A			A	A	A	A	S	A	A	A	A	S	A			A	
Set up a Company Intranet	A	A	A			A	A	A	A	S	A	A	A	A	S				A	
Create a Cluster	A	A	A			A	A	A	A	S	A	A	A	A	S	A			A	
Setup an Online Catalogue	A			S								A	A							
Create an Auction		S										A	A							
Create an Bazaar			S									A	A							
Develop new Business	A			A								A	A			A	S		A	
Training (S)																				
Key / Notes	S= Standard Modules A= Recommended Modules										Training to be given as and when modules used									

Table 6 – Collaborative Toolset Framework

In addition to the synchronous Low Cost Virtual Teaming collaborative system, (discussed in section 5.4), a subset of the system modules are specifically used to undertake asynchronous communication. This is the primary type of collaboration used in the toolset and hence the overall Collaborative Architecture, including:

1. Announcements – broadcasting notices to community members

2. Contacts – manager and shared project member details
3. Discussion forums – interaction in forums through threaded discussions
4. Document storage – manage and share documents
5. Events - shared and manage events in a calendar facility
6. Tasks – allocate and manage project tasks and activities
7. News feeds – create automatic dynamic content through links to syndicated news via RSS or RDF standards.

Within the toolset, a scalable security access model underlies user authentication to project portals, which allow members to create online spaces containing system modules that generate the user outfacing content. This allows regional e-marketplace members such as WMCCM to move along the sliding scale depending on the portal access requirements. Users can quickly create a wide range of website portals from Intranets for internal company use, to fully public Internet sites with an incremental spectrum in-between. This is indicated in Figure 13.

Two different standard portal templates are available which facilitate the creation of portals. The project portal template is based on closed online space with access being given on an individual basis. Cluster portals are open by design allowing public sites to be created. However either one of the two types of portal can contain pages which are open to the public or closed.

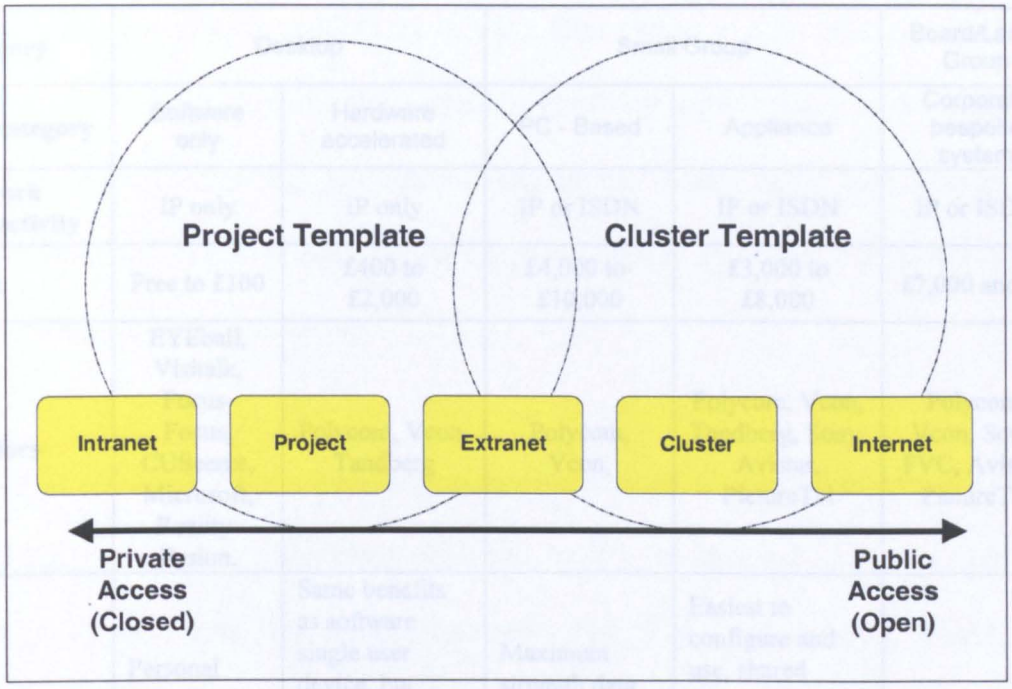

Figure 13 – Collaborative Portal Model

5.3 Technology Selection

The cost of implementing and running VT and concurrent engineering had previously restricted it to the higher echelons of the supply chain. Various prior field studies have been undertaken before in the automotive Virtual Teaming area, for example by Bal [13] and May [18]. However, these are focused primarily on the larger corporations and the higher end of video conferencing systems needed to enable VT. An overview of the types of collaboration available, including estimated cost and pros and cons, can be seen in Table 7.

In order to ascertain what was the most appropriate system for automotive SMEs, a simple technology selection process was undertaken using a number of steps. This approach was taken due to the large number of Video Conferencing / Data Conferencing systems on the market.

Category	Desktop		Small Group		Board/Large Group
Sub-category	Software only	Hardware accelerated	PC - Based	Appliance	Corporate bespoke system
Network connectivity	IP only	IP only	IP or ISDN	IP or ISDN	IP or ISDN
Costs	Free to £100	£400 to £2,000	£4,000 to-£10,000	£3,000 to £8,000	£7,000 and up
Vendors	EYEball, Visitalk, Focus-Focus, CUSeeme, Microsoft, Reality-Fusion.	Polycom, Vcon, Tandberg	Polycom, Vcon,	Polycom, Vcon, Tandberg, Sony, Avistar, PictureTel	Polycom, Vcon, Sony, FVC, Avistar, PictureTel
Pros	Personal system assigned to one user. Desktop based so easy access.	Same benefits as software single user device, but more expensive hardware and integrated with data conferencing applications. Desktop based so easy access.	Maximum strength data collaborative environment, flexible as can be used when not in video conference	Easiest to configure and use, shared resource in meeting room, can be effective for presentations, frequently includes built in MCU	Quality closest to the 'being their experience'
Cons	Very Dependant upon existing PC performance and bandwidth availability.	Same as for software only, lowest audio and video quality, (data rate a function of PC and connectivity). Does not exceed 512k bit/sec rate	Easily tampered with, potentially difficult to set up, slightly higher cost for presentation functionality	Limitations to data conferencing, is not used for anything else when not in video conference	Highest cost, lowest flexibility

Table 7 – A Comparison of Video Conferencing System Types

Many Video Conferencing systems available are aimed at the large expensive corporate market, for example Avistar and PictureTel. However, the principle criteria for the target SMEs is low cost. The corporate systems could be eliminated very early on in the selection process due to their prohibitive purchase price and running costs. There has been a proliferation of Internet desktop video conferencing solutions in

recent years, as software vendors try to stake their claims in a growing marketplace. Until recently, the quality of video and audio conferencing over the Internet was very poor. However, technology is quickly changing and improving in this sector to the extent that users can now expect good telephone quality audio and reasonable video over a dialup modem connection.

A high-level review of approximately sixty-five desktop IP-enabled potential Virtual Teaming systems was undertaken, followed by a more detailed analysis using the Quality Function and Deployment process. This high-level review reduced the number of systems to five. Regardless of the large number of video conferencing software packages available, it was found that only a small number met the requirements of the SMEs. In particular, the ability to use collaborative tools at low cost had been found in only a small minority of the sixty-five products evaluated. This feature was mainly the preserve of the large 'studio based' and 'corporate focused' expensive systems.

A more comprehensive assessment was undertaken of the remaining five systems, supported by a QFD (Quality Functional Deployment). See Appendix E for a listing of collaborative systems assessed. The QFD process systematically assesses the relative importance of customer requirements of a product against its technical features and functions. The process quickly determines which video conferencing product specification is most suitable for the application and use by manufacturing based SMEs. The user (customer) requirements identified for the system were:

- Low cost or free.

- Audio and Video Conferencing.
- Collaborative tools such as a virtual white board, shared application capability, file transferring and Internet Relay Chat.
- Compatibility with existing systems.
- Ability to work with low or restricted bandwidth.
- Technical support and active product development from the vendor to ensure longevity.

The assessment for the remaining five systems measured against the customer requirements and the results gained from SMEs (the customer) can be seen in Table 8.

	Weight	CUSeeMe World v1.0		Eyematic iVisit v2.563		Marratech Pro v2.1		Microsoft Netmeeting v3.1		Visitalk	
		Rating	Points	Rating	Points	Rating	Points	Rating	Points	Rating	Points
Ability to Utilise Low Bandwidth	8	M	40	H	80	H	80	H	80	M	40
Audio	10	M	50	M	50	H	100	M	50	M	50
Compatibility with Other Systems	8	M	40	L	0	L	0	H	80	M	40
Ease of Use (Installation, Configuration and Operation)	5	H	50	H	50	L	0	M	25	M	25
File Transfer Capability	5	M	25	L	0	H	50	H	50	H	50
IP Compatibility	8	H	80	M	40	H	80	H	80	H	80
Low Cost	10	M	50	H	100	L	0	H	100	M	50
Peer to Peer Architecture	5	L	0	H	50	L	0	H	50	L	0
Security	8	L	0	M	40	H	80	H	80	L	0
Shared Applications	8	L	0	L	0	H	80	H	80	H	80
Technical Support	10	H	100	M	50	H	100	H	100	M	50
Video	5	M	25	M	25	H	50	H	50	M	25
Whiteboard	10	L	0	L	0	H	100	H	100	H	100
Widely Available	5	H	50	M	25	L	0	H	[illegible]	M	25
Total Score			510		510		720		975		615

Table 8 - QFD to Select Low Cost Virtual Teaming Toolset for SMEs

This approach to the research links into grounded theory. It sought to highlight the reality through a number of initial company visits and subsequently arrive at a usable

proposal. Once the proposal was developed, it was taken into the field and made available for comment and amendment by users.

5.4 Low Cost Virtual Teaming Toolset

The QFD process resulted in a Virtual Teaming solution being recommended to and subsequently approved by the Autocle@r project steering committee.

The developed system comprised of Microsoft NetMeeting, Microsoft MSN Messenger and MSN Communities components. Development and configuration was undertaken through the NetMeeting System Development Kit (SDK), which allowed a bespoke and tailored preconfigured version of Net Meeting to be built.

The Low Cost Virtual Teaming system in operation can be seen in Figure 14.

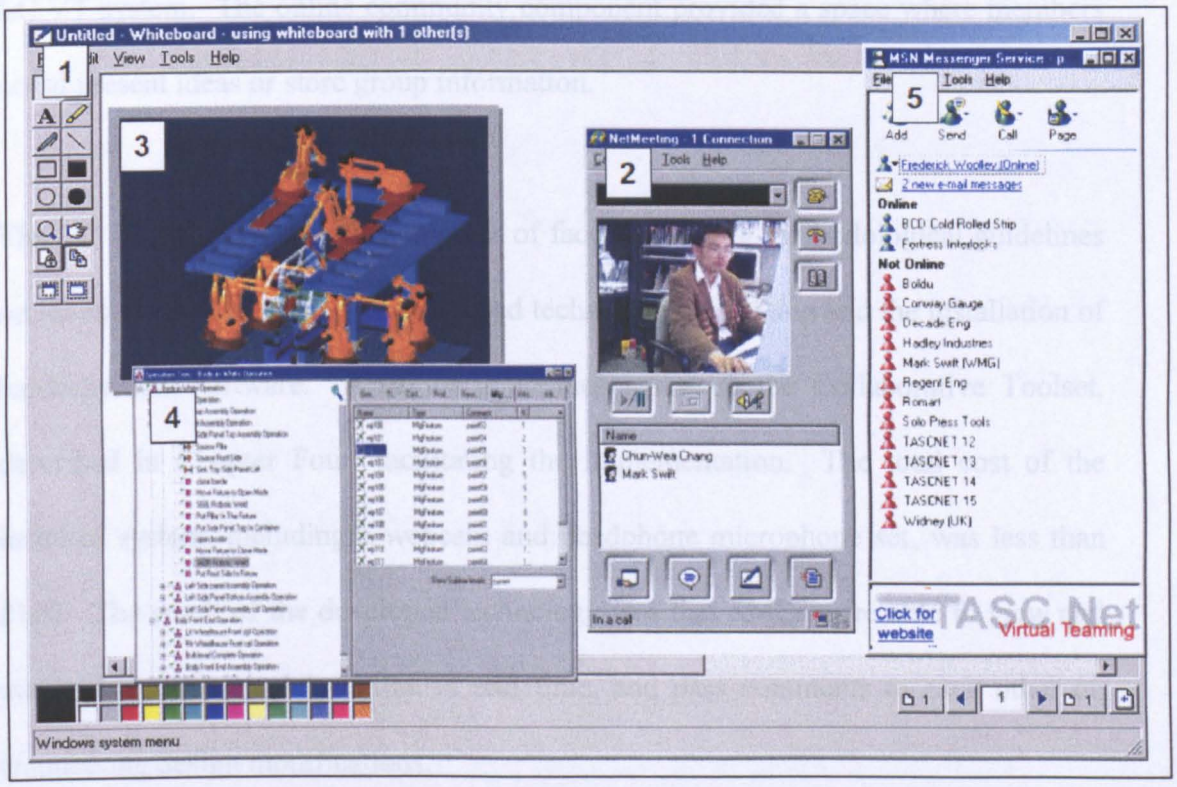

Figure 14 - The Low Cost Virtual Teaming Interface

The Collaborative Toolset components indicated in Figure 14 are as follows:

1. Virtual Whiteboard
2. Audio / Video features
3. Remote Application Sharing
4. File transfer
5. Directory of other Virtual Teaming users & Instant Messaging

Each component played an important part in the collaborative solution. NetMeeting featured video, audio and a whiteboard allowing synchronous communication with the SMEs on the Autocle@r project. Messenger facilitated ad hoc meetings to be started and one to one or one to many text chats through its presence detection feature. This feature was particularly useful to determine availability of team members, and it was noted that shorter more frequent meetings were taking place than before installation of LC VT system. The online community component provided a space where members could present ideas or store group information.

The LC VT setup comprised a number of facets including methodological guidelines on the systems setup and use, the desired technical specification and the installation of hardware and software. A set of guidelines make up the Collaborative Toolset, described in Chapter Four, facilitating the implementation. The total cost of the installed system, including a webcam and headphone microphone set, was less than £100. The result of the developed technology was that SMEs were able to view and manipulate CAD models online in real time, and pass comments to each other on engineering design modifications.

5.5 Validation of Collaborative Toolset

SMEs face greater risks in IT implementation and adoption than large businesses, due to inadequate resources and limited technical ability. It was found during the course of Autocle@r and TASC Net that many SMEs have basic problems with PC technology, often having out of date hardware and software.

Many technical issues had to be resolved in order to ensure that the system gave optimum performance. These issues were impeded by the technical and knowledge constraints of the SME. A strict implementation process evolved during the Autocle@r project to ensure implementation could be completed as efficiently as possible (see Submission Four for details). Additionally, the technical specification of the Low Cost Virtual Teaming system evolved due to a further understanding of the SME requirements and their environmental conditions.

There were many barriers encountered during the project which impeded the successful use of the system by the SMEs. Resistance to change was a particular issue; the use of 'Change Champions' played an important role in facilitating the adoption and growth of the system. Thus, identifying and nurturing the 'Champion' was critical, increasing the likelihood of the project's success. This was evident particularly within the 'plastic moulding cluster'.

The adoption of novel collaborative Virtual Teaming tools with accompanying novel practices and processes is not easily achievable. From the practitioner's perspective, the project experienced moderate success with 38% of the project participants adopting the LC VT system following implementation.

However, this research has proven that it is possible to use the Internet, with limited bandwidth, at low cost and with little technical knowledge, to undertake online collaboration between SMEs. For the first time, SMEs have access to a system that can facilitate collaborative working between geographically remote partners, customers and suppliers. This is an innovative application and method of working for SMEs.

During the course of the Autocle@r project, a significant increase in the mode average bandwidth available was experienced for Virtual Team meeting from 33Kbps to 48Kbps. However, when operating at these levels, it is appropriate to use the collaborative applications sparingly and thus a set of guidelines were provided to help with this.

The increasing availability of broadband bandwidth through Asymmetric Digital Subscriber Line (ADSL) and cable modem connections means overall performance and richness of interaction will only get better. The outputs of the project, and hence this submission, generated considerable innovation. This can be identified as:

- Identification, development and application of a new and innovative method of working for SMEs.
- The Low Cost Virtual Teaming system provided new ways of working, presenting new opportunities to improve relationships with existing and new partners.

5.6 Low Cost Virtual Teaming Analysis

Within the trial group of thirty SMEs, a number of subgroups or 'clusters' have been formed that allow existing business relationships to be managed and also the initiation of new ones. This has resulted in cluster members being able to reduce costs and time wasted through decreased travel costs.

With the formation of the clusters, SMEs were able to actively share information and knowledge across parts of their supply chain. Engineering data on a new product being developed was exchanged across the cluster, from the tool designer in one business to the pressing and assembly manufacturer, via the toolmakers. Once the cluster developed further, it became possible to extend the information-sharing to new businesses who had not previously worked with these companies.

As with most new technologies, their effectiveness becomes enhanced once a critical mass of users is reached. Thus, Virtual Teaming system usage by each SME increased once these clusters began to grow beyond three or four members. It was therefore actively encouraged, with the consent of existing members, to introduce new members to the group.

SMEs within the Autocle@r project gained capability to show components via their webcams and look at drawings and quotations while working simultaneously with other partners. A toolmaker could view a component's digital photograph and annotate it simultaneously while talking to and seeing the remote user.

The technology provides easy to use capability and is compatible with most other systems, at low cost. Making effective use of it requires fine-tuning of procedures internally and externally.

LC VT provided new ways of presenting new opportunities to improve relationships with existing & new partners. However, many issues were encountered with SMEs and IT capability during these projects:

- At the time of the project, the synchronous technology was immature.
- SMEs were not ready to undertake synchronous collaboration, it is better initially to adopt asynchronous collaboration tools.
- The adoption of novel collaborative SME centric Virtual Teaming tools with accompanying novel practices and processes is not easy.
- 38% of the project participants adopted the LC VT system.
- Bandwidth was an issue with the early adopters but improved significantly during the project. Broadband is today more widely available and hence bandwidth less of a concern.
- SMEs had poor IT resources and capability in many cases.
- It was difficult to change existing work practices and thus the approach recommended is to concentrate on new work / tasks / jobs first.

This system enabled SMEs to be able to use VT and collaborative environments for the first time and resulted in identification and application of a new method of working for SMEs.

Considering these issues, the technical complexities of implementing the Low Cost Virtual Teaming solution and the overall marginally successful implementation, a staged technology evolution roll out path can be devised. This is suggested due to the time it takes to establish the disciplined processes required to adopt LC VT and the technical complexities, skills and competencies required for the majority of SMEs. These points were particularly prevalent on the Autocle@r project. Therefore the steps on the evolution path to adopt the collaborative working practice in manufacturing based SMEs should be:

1. Become a member of WMCCM, gaining access to online functionality such as the asynchronous collaboration and project management tools.
2. Once familiar with asynchronous tools and benefits, evaluate the adoption of synchronous tools through simple instant messaging.
3. Finally adopt, where applicable, full synchronous collaboration through the Low Cost Virtual Teaming tool, in conjunction with a disciplined and pre-defined process.

5.7 Conclusions

LC VT enables collaboration between parties, in different locations, from initial design discussion through to the product development process and the manufacture of the component or system. The Toolset contains a range of asynchronous and synchronous technologies to enable this. The overall benefit of the Toolset is the prospect of SMEs being able to collaborate in the same manner, and reap similar rewards, to those of larger corporations. This can facilitate concurrent engineering by enabling the co-ordination and integration of design activities with customers and

suppliers. The impact of cascading this technology, allowing rich relationships to develop and virtual centres of excellence to be formed could prove significant.

This approach allowed SMEs to share their knowledge and information with other enterprises irrespective of location. The toolset facilitates the move from "components to systems" through a collaboration approach and the provision of online IT systems and Collaborative Processes linking into the overall Collaborative Architecture. For many SMEs to achieve smooth adoption of collaborative practises, an evolutionary and progressive path should be taken. One success of the project resulted in an SME participant of the Autocle@r project requesting for it to be extended and the system implemented within its own network of ten suppliers and customers.

This next chapter discusses the innovative aspects of the work.

CHAPTER SIX

INNOVATION AND DISCUSSIONS

6 Innovation and Discussions

The core theme of the portfolio is inter-firm collaboration, where architecture, technologies and practices have been studied, devised and evaluated. The context has been within manufacturing based SMEs, many of which serve the automotive component supply industry.

Innovation was required to bridge the increasing gap between the larger companies (OEM and 1st Tier) and SMEs in terms of business practices and technology. Aspects of this gap were:

- The larger companies demand engineered systems rather than "single component parts". This requires a higher level of collaboration between partners in order to deliver complex engineered systems and a more complete service.
- Buy-side Industry e-marketplaces, created by the OEMs and 1st Tier suppliers, to increase competition among suppliers, utilising shared sourcing databases and tools such as reverse auctions to drive purchase costs lower. These e-marketplaces are industry focused, for example aerospace or automotive, whereas SMEs are not.
- Increased demand on the breadth and depth of skills required from the SMEs in order to deliver complex engineered systems means that SMEs have to look at ways of acquiring new skills and expertise.
- Investment in IT systems was required by the SMEs to provide the collaboration required, but was hindered by their lack of IT skill know how and resources.

The research methodology adopted was designed to ensure that any innovation developed was need driven. Thus, it was the research methodology and numerous company visits, through assistance projects such as AutoLean III, Autocle@r, TASC Net and the West Midlands Collaborative Commerce Marketplace (WMCCM), that identified suitable responses to industry pressures.

6.1 Research Issues

Innovative aspects of the project include the development of a Low Cost Virtual Teaming system for Small to Medium sized Enterprises (SMEs). This system was devised and tested within SMEs in the automotive supply chain in the West Midlands, UK. Typical SMEs were able to use web enabled collaborative technology to enable concurrent engineering activities between suppliers, customers and partners at low cost, with little training. A comparison with other products showed significant cost and usability advantages.

The project has identified a number of issues, analysis of which has contributed to the research work and subsequent innovative aspects:

- Suitable systems for SMEs need to be low cost, practical to use, tested and proven within their capabilities.
- Existing e-marketplace models have experienced a high level of failure, being unable to generate sufficient revenue to cover their costs, and to leverage enough loyalty from companies who want to join. Why should an SME join a UK SME e-marketplace or a Metal Forming e-marketplace? The new model seeks to address these issues through exploiting regional identity and loyalty.

- Another reason why e-business has largely failed to succeed in the manufacturing based engineering sector (in particular the SME engineering sector) is that existing e-business is directed at businesses that make or sell products. E-business models are usually catalogue based. Small engineering businesses do not make or sell standard products, have a standard product range or a product catalogue. Most products are made as an output of detailed collaboration between customers and suppliers. In traditional automotive SMEs by far the largest part of the engineering based SME sector in the West Midlands region [26] their business is primarily product manufacture. Within these SMEs there is evidence to suggest that they are active users of electronic collaborative working or Virtual Teaming.
- The research projects identified that many manufacturing based SMEs have a range of competences and skills that can be utilised to make unique, customer specific products, leading to higher margins than their existing output.
- The conventional tools for enabling collaboration, such as PTC Windchill, EDI, Louts QuickPlace, Groove etc are too expensive and complicated for small businesses. Large organisations, however, have IT departments that can configure, manage and provide the support these systems require. The innovation is the way in which connections, in a generic low cost way are made to people in other departments or organisations, as opposed to other information systems. Though the first step in collaboration is the establishment of relationships between people, it is important that IT support is available to all relevant users so they can comfortably maintain these relationships. Only once relationships are in place is it possible to start using integrated IT systems between different organisations effectively.

- There has been much previous work on Virtual Teaming in the late 1990's by authors such as Lipnack & Stamps [7], Duarte & Snyder [15] etc. The TEAM [13] and VTASC [18] projects at University of Warwick for the automotive supply chain and the Boeing-Rocketdyne project [39], focused mainly on the issues and benefits for large corporations. This is often the viewpoint because only large corporations could afford the cost of the collaborative working solution available. Examples of using Virtual Teaming and other electronic methods of collaboration, within SMEs are very limited.
- Existing Virtual Teaming literature is mainly aimed at business executives rather than engineers, and hence this research is focused on the specific needs of manufacturing based SMEs. The instances of Virtual Teaming within SMEs are focused on engineering consultancy companies, whose business activities are centred upon the application of knowledge [13]. Engineering collaboration requires a high level of multifunctional interaction for problem solving, such as online manipulation and the exchange of engineering design data, which involves more complex processes than those addressed by the Virtual Teaming published authors.

6.2 Main Areas of Innovation

The research undertaken included literature review, industry and technology analysis, interviews with acknowledged experts and many company visits and interactions for installation, demonstration, training and monitoring. This immersion in the subject and the issues has led to the following areas of innovation:

6.2.1 Innovation 1 – Regional e-marketplace Model

The new regional e-marketplace model allows SMEs to access e-opportunities, showcase regional capability and exploit regional loyalty and identity. Such a regional e-marketplace for SMEs is part of the local infrastructure, in the same way as major road junctions, railway stations, airports etc. The fact that a region will be economically disadvantaged without one has received wide acknowledgement. Subsequently the cost to the SMEs is free.

The need for an electronic SME e-marketplace was recognised as early as the mid 1990s when there was a G8 project to develop the requirements and architecture for such a model. Countries such as Singapore, South Africa, the USA and others have been developing such e-marketplaces. These initiatives however failed to recognise that for manufacturing based SMEs, their products are only one illustration of their skills and capability. What is really needed is to capture what they could do, i.e. their potential, not just what they do already. They also failed to generate the levels of trust required to encourage activity on the e-marketplace.

The Collaborative Architecture addresses these issues through capturing and understanding the processes and skills of individual manufacturing SMEs (their competence). This forms a list of competences and skills that is promoted to members and non-members to seek partnering opportunities. Promotion would include process catalogues rather than product catalogues.

6.2.2 Innovation 2 – Virtual Team Methodology

A detailed methodology for introducing Virtual Teaming in Manufacturing based SMEs was developed and implemented from reviewing, refining and adapting

industrial practice and academic literature in this research field. In general, there is a visual culture in engineering since team members communicate ideas through sketches, and often need to refer to drawings and design to accomplish their work.

In addition to the methodology, SMEs have support from a comprehensive set of guidelines and tools that facilitated the use of this collaborative technology.

6.2.3 Innovation 3 – Low Cost Virtual Teaming System

The research included the development, implementation and testing of a Low Cost Virtual Teaming system for Small to Medium Enterprises (SMEs). Compared with the other collaboration systems available, this system has a unique combination of benefits, which include:

- Low Capital costs- free
- Low running costs - free
- High functionality – includes whiteboards, video and audio.
- High compatibility – works with industry standards
- Good usability – specifically pre-configured for SMEs requirements

A summarised comparison of the LC VT system against a number of other video conferencing systems is shown in Table 9. A full listing and comparison of over 60 systems can be seen in Submission 3A and is listed in Appendix E.

	LC VT System	CU See Me	Polycom
Capital costs	*Low* – Free	*Low* - Free	*High* – from £4,000 to £10,000
Running costs	*Low* – Free	*Low* - Free	*High* – Licensing model
Functionality	*High* - Electronic Whiteboard, file transfer and shared application.	*Low* – No collaborative features to support visual manipulation of images / designs	*High* – Electronic Whiteboards
Compatibility	*High* – works with H323 & H324 standards	*High* – works with H323 & H324 standards	*Low* – only works with other Polycom systems
Usability	*Good* – Windows "look and feel", supports low bandwidth infrastructure	*Good* – quick to setup, supports low bandwidth infrastructure	*Poor* – requires multi ISDN lines or broadband

Table 9 – The LC VT system and its peers

This system was applied within SMEs in the automotive supply chain within the West Midlands region of the UK. For the first time, SMEs were able to use web-enabled collaborative technology to enable concurrent engineering activities between suppliers, customers and partners.

After people relationships are established, it is possible to start undertaking systems integration activities between different organisations. Suitable systems for SMEs need to be low cost, practical to use, and tested and proven to be within the SME's financial and technical capabilities.

6.3 Relevance of the Innovations

The author believes that the research work introduced is of crucial relevance to the target market of manufacturing based SMEs. This research addresses the following key concern areas:

6.3.1 Finding New and Better Quality Business

The regional e-marketplace architecture is a good platform for enabling the UK government directive for local sourcing from public bodies. European Public Tenders (OJEC) are already provided through the WMCCM e-marketplace, as well as tenders originated from other commercial partners. Currently there are over 1,500 live tenders on the system. In addition, the system supports local sub groups, such as industrial estates, which subcontract work among themselves. Given that the system is focused on what companies can do, not just on what they do at present, it provides the opportunity to identify possible new suppliers, customers and partners.

6.3.2 Finding Partners to Undertake Work

There is a need to find and establish relationships with partners quickly and with confidence. The Architecture and Processes devised enable quick searching and contact with prospective partners, having validated their skills and capability. The partnership search facility devised for the WMCCM e-marketplace is unique and is not found in contemporary models.

The finding of partners benefits the members of the e-marketplace by addressing trends such as:

- Sourcing systems rather than components, by accessing complementary partners in order to acquire skills, tacit knowledge and know-how.
- Managing more of the relationship such as providing assembly workers at the customers premises, or access to live production and quality data
- Faster responsiveness

6.3.3 Collaborate at Lower Cost

Having found partners, it is essential that the costs of managing the collaboration do not exceed those of the relative inefficiency of doing the task independently. Historically, companies have faced the "make or buy decision" for all necessary tasks. The trade-off is the relative inefficiency of doing it yourself versus the specialist provider, against the extra costs of managing the outsourcing relationship. A good collaborative platform, such as WMCCM, built to the architecture devised, can lower the costs of managing the relationship through improved visibility and communications. This was evident at Regent Engineering who was able to reduce lead times and problem resolution time significantly through using the LCVT system within the regional e-marketplace [49]. It can also enable aggregated purchasing and access to tools such as reverse auctions which have been proven to provide purchasing savings of around 20%. However, the biggest benefit of improved collaboration is reduced time to market.

6.3.4 Business Benefits to Example SMEs

The following examples are real companies who are members of WMCCM, although their names have been changed to protect confidentiality. However these examples could apply to a typical set of different SMEs types, mainly Micro, Small and Medium with different business focus and levels of ICT maturity.

6.3.4.1 Market Engineering Ltd

Market Engineering are pressed metal component and assembly manufacturers, who pride themselves on being able to offer services from design concept, through prototyping and testing, to medium volume supply. They are a medium sized SME with a turnover of £3.2 million and employer of 65 staff. An active company, they

have won various supply chain awards with a relatively well-developed marketing centric website. The majority of their engineered parts are custom manufactured to customer specifications, however, they are unusual making a number of made to stock products for the security industry. The Collaborative Architecture and thus the innovation apply to them in the following ways:

- The printed catalogue of standard parts was not available online nor was it widely marketed or exposed. The regional e-marketplace toolset allows them to develop an electronic catalogue which can be made visible to members and non-members of the site. This will allow existing customers to always have the latest product data sheet in addition to the catalogue being exposed and channelled to a larger market of potential customers. Additionally, the e-marketplace would promote the catalogue content using various search engine optimisation and marketing techniques as part of an e-marketplace wide strategy.
- Identify and collaborate online with international suppliers to produce high volume security products and pass on a significant cost reduction to their customer. They would additionally seek to retain product design and development functions, whilst continuing as the "manufacturing process expert". If they do not work in partnership with competitors in low cost economies then there is a real danger of being deselected by their customer.
- The new product development process for new pressing and assemblies is both time-consuming and complex, involving many partners over a long period. This conventionally was done via FAX, phone and frequent face-to-face meetings. The e-marketplace enables Market Engineering to set up an extranet for new projects as they come along. This allows Market Engineering to keep track of the latest technical drawing releases via the documents function and allocate tasks to

individuals through the task function. Project members, such as press tool and machine tool manufacturers and the customer, can go online and view the status of the relevant part of the project. Travelling time, meeting preparation time and time wasted because the right expertise may not be accessible during the meeting, is thus reduced.

- Setting up the collaborative extranet required all the project partners to join the e-marketplace. The secondary effect of this was that both toolmakers gained high Internet presence which they did not have before thus facilitating search engine optimisation and marketing.

6.3.4.2 AC Design Ltd

AC Design, a micro SME, are a specialist plastic injection moulding tool designer employing just two members of staff. They have no Internet presence and are located in a quiet residential area with no passing trade. The majority of their work is with long standing customers and marketing is rare, with new work gained usually through word of mouth. The innovation applies to them in the following ways:

- The e-marketplace will also benefit AC Design by allowing them to behave in a way be fitting a larger company, through providing partners with sophisticated and expensive corporate level online tools.
- Resources are very limited for a small firm with priority given to spending time on the "value creation" part of the business – i.e. design. If AC Design needs to find new partners for a new area of work, partner identification and selection can be undertaken using the competence profiling facility. This cuts through the uncertainty of sourcing "cold", and bypasses conventional marketing information providing validated, structured supplier information. For a small firm this offers

substantial time savings. This same benefit has also been realised by the managing director of a small engineering company in Wolverhampton. [50]

- Membership of the regional e-marketplace allows AC Design to gain quick access and exposure to new business opportunities. This differs from building their own website since they are exposed in a public Internet space with much passing trade in the form of other e-marketplace members. An analogy is setting up a store in a large shopping centre (the e-marketplace) rather than the back street (the Internet). The Google search results can be seen in Figure 15. Since significant e-marketing, website configuration and optimisation has been carried out for WMCCM, the information stored is indexed regularly by the Google search engine robots. This means that AC Design does not have to worry about doing search engine optimisation and marketing work themselves, benefiting them by gaining greater market exposure. In existing and current markets, AC Design are able to promote themselves more actively than previously, using the online tools provided through the e-marketplace.

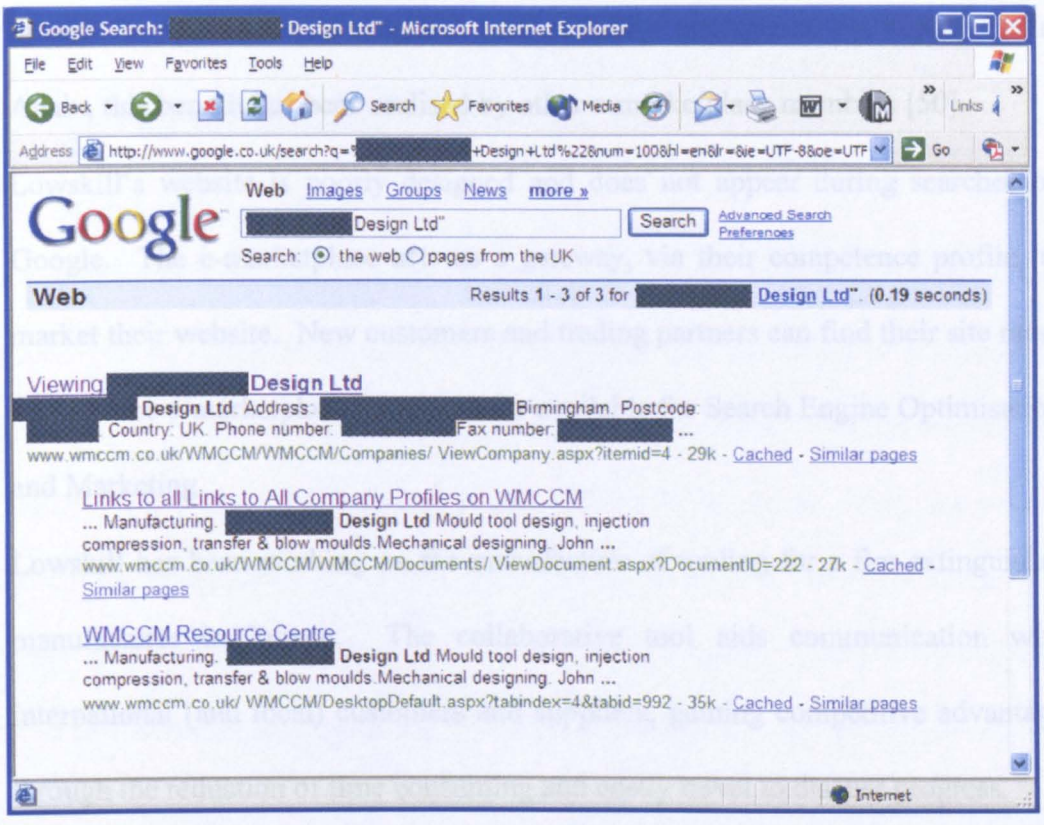

Figure 15 - AC Design Google Search Results via WMCCM

6.3.4.3 Lowskill Ltd

Lowskill Ltd are a small toolmaker, employing eight staff and turning over £500,000. Over the last two years, business has taken a down turn and they have made a number of compulsory redundancies. Even though they have lost a couple of key customers, they never seem to have time or the skills to pursue new business opportunities or engage in marketing activities. They work with a range of clients both nationally and internationally. Work has recently increased and now they do not have enough production capacity, due in part to their recent downsizing. The innovation applies to them in the following ways:

- The e-marketplace helps Lowskill to find new partners to outsource some of their work, saving both the time and effort normally required to search the Internet, Yellow Pages etc. Fundamentally, this allows more informed decision-making

through better market intelligence and visibility throughout the supply chain. Again, this benefit has been realised by other e-marketplace members [50].

- Lowskill's website is poorly designed and does not appear during searches on Google. The e-marketplace acts as a gateway, via their competence profile, to market their website. New customers and trading partners can find their site more easily. The e-marketplace has resources available for Search Engine Optimisation and Marketing.
- Lowskill has been working on the manufacture of tooling for a fire extinguisher manufacturer in France. The collaborative tool aids communication with international (and local) customers and suppliers, gaining competitive advantage through the reduction of time consuming and costly travel to discuss progress.
- Even though work has recently increased, there is no guarantee that this will be sustained in the medium to long term. Therefore, Lowskill signed up to the tender feed from WMCCM allowing them to have exposure to new markets.
- Overall, WMCCM offer Lowskill a one-stop place for new trade, marketing and collaboration opportunities.

6.3.5 With the Automotive Industry

Within the Automotive industry, collaboration is mainly driven by the needs of the larger OEMs and 1st Tier companies. To enable the average automotive SME to participate as required by these end customers requires considerable financial, technical and process investment. In essence, it requires SMEs to join several e-marketplaces, each with their own joining fees, technical standards and operational processes. The architecture and tools proposed reduce this need significantly. The regional e-marketplace architecture reduces these requirements by acting as a gateway.

The paper written for The Manufacturing Engineer [37] explains this in further detail (see Appendix F for the paper in full)

6.3.6 Within Other Industries

The fundamental design of the Collaborative Architecture is the identification and promotion of necessary tasks, and the identification and allocation of resources to undertake such tasks. Within the regional e-marketplace, the tasks are the tenders and the resources are the manufacturing based SMEs. With this in mind, the overall Collaborative Architecture has been proposed for application in other industries. It is currently being assessed for the Food & Beverage industry, Creative Media, and Professional Services sectors on the Gateway Asia project (www.gatewayasia.com). The architecture has also been proposed for use by the Kent Highway Agency Services and for running and operating Warwick Manufacturing Group's full time postgraduate teaching program.

The Collaborative Toolset has also seen interest from companies outside the automotive industry. For example, the Gas and Water National Training Organisation commissioned from the author a system for seven remotely based programme managers to be connected to their headquarters. The benefit of this work was the ability to work closer through frequent communication with the programme managers, resulting in them being able to react more quickly to changing demands and improve their overall training efficiency.

6.4 New Processes, Materials, Techniques and Procedures

A number of processes, materials, techniques and procedures have been developed during the EngD including:

- Demonstrators have been built during the project to show how the technologies can be used by SMEs. For example, the TASC Net community of SMEs is currently using the Low Cost Virtual Teaming system in its network of ten companies. This project provides a case study and an example for other SMEs to see, which could encourage them to roll out this system within their own environments.
- Identification of e-business migration path for SMEs. The Collaborative Architecture acts as a framework for small businesses to use in order to develop their e-business competencies. By participating in the regional e-marketplace, SMEs can step up from using e-mail to e-business capabilities, with no financial investment.
- An overall architecture featuring a regional e-marketplace model. Funding of £3.6 million has been secured for a regional e-marketplace in the West Midlands area (WMCCM).
- Development of a number of collaborative demonstrators. During the Autocle@r and TASC net projects a Low Cost Virtual Teaming system was developed, implemented and tested within approximately twenty small companies. The system comprised tailored and preconfigured solutions specifically for SME requirements, and used Microsoft NetMeeting, Microsoft MSN Messenger and MSN Communities. This resulted in a proven system that can be easily used by SMEs at little or no cost. These demonstrators provide an important illustration and a way of persuading small companies what they could do and what can be achieved.

6.5 Dissemination of Research outcomes

Although these bring value in their own right, in order to realise any business benefit they must have been applied. This and the following section describes the dissemination and application of the research. There are a number of dissemination outcomes, such as:

1. Following dissemination of the regional e-marketplace Collaborative Architecture, positive feedback on the model has been received. For example this has resulted in the Southall (West London, UK) Regeneration Partnership setting up Gateway Asia (www.gatewayasia.com) using the EngD research. The application will test the capability of the Collaborative Architecture, Processes and Tools devised by this research to help link SMEs in the UK with SME partners in India, China, Malaysia and South Africa, among others. Over 600 organisations have already been recruited. Four sectors have been targeted: Food and Beverage, Media, Professional Services and Light Engineering. Hence, the research work will be used and further tested in other sectors as well as the manufacturing / engineering sector originally envisaged. Gateway Asia is supported by, among others, The London Development Agency, Trade Partners UK, West London Business and Business Link for London. Currently being implemented, it presently has 600 members

2. Negotiations for the formation of other e-marketplaces using the Collaborative Architecture research is being sought. Strong interest for e-marketplaces, in regions such as the North East (UK), South Wales (UK), Malta and the Pacific

Islands (Fiji), is being expressed by Government and Non Government Organisations (NGO).

3. A paper has been published within the Manufacturing Engineer Journal, by the IEE, on the thinking behind and the development of the West Midlands Collaborative Commerce Marketplace (see Appendix F) [37]. The journal is read mainly by practitioners across manufacturing sectors, who seek to access current thinking and best practice.

4. A paper on the regional e-marketplace concept has been presented in the E-challenges International Conference in Bologna, Italy during October 2003. This is the official conference of the Information Society, an initiative of the European Union [52]. This conference was attended by over 500 delegates from commercial, government & research organisations around the world in order to share knowledge, experience, lessons learnt and good practice.

5. At WMita (West Midlands Collaborative Commerce Marketplace) Conference, a presentation was made in December 2001 on the use of the Low Cost Virtual Teaming system within small businesses [51]. This led to a number of enquiries for the methodology and how the system could be rolled out, with requests for a number of commissioned projects. As a result, this organisation has now become a partner of WMCCM and has over 250 IT SME members in the West Midlands.

6. A list of further industry dissemination undertaken as part of the research can be seen in Appendix A.

6.6 Application of the Research

The research innovation was applied in a number of different areas during the EngD programme:

6.6.1 Application One: Autocle@r Project – Sept 2000 to Nov 2001

The developed Low Cost Virtual Teaming system was implemented within 20 SMEs in the West Midlands automotive supply. These companies varied considerably in size, nature of business, level of IT maturity and experience.

6.6.2 Application Two: TASC Net Project – July 2001 to Sept 2001

This application of the Low Cost Virtual Teaming system was within the closed supply chain of SME, Frederick Woolley Ltd. Ten companies, employing between 10 to 600 staff and representative of different industrial sectors, used the Virtual Teaming system to improve collaboration during the product development process. Additionally, they used the system for training and learning purposes within their closed supply network.

6.6.3 Application Three and Four: CPC Module – Sept 2001 to Date

The Low Cost Virtual Teaming system has been applied on the Collaborative Product Commerce (CPC) module for the Full Time Masters of Science Degree in Electronic Business Management, course run by Warwick Manufacturing Group, University of Warwick. The majority of the students on this course are from overseas where English is not their first language and they had varying levels of technical experience. A case study was developed which resulted in the students using the Low Cost Virtual Teaming System to resolve an engineering based problem. Additionally, the students had access to the collaborative process methodology and an online product library containing technical information to help them resolve the case study scenario.

Students were split up into several syndicate groups, to play the role of either a supplier or large automotive manufacturer. This module session was run twice during 2002, 2003 and 2004 and will run three times in 2005.

6.6.4 Application Five: Regional e-Marketplaces - June 2002 to Date

The innovative and industrial relevance of the work was identified early on and as a result, ERDF funding was secured to build a regional e-marketplace for the West Midlands region over a four year period. The West Midlands Collaborative Commerce Marketplace (WMCCM) currently has 1,500 companies registered.

More recent developments include Gateway Asia (www.gatewayasia.com) and a pan European polymer and plastics processing network (PlasTeam) comprising experts and 300 SMEs from 10 European Union member states – www.plasteam.org.

6.6.5 Findings

A number of findings were highlighted during the application process. A selection is as follows:

- Manufacturing based SMEs need to remain competitive and offer more to their OEM customers through the provision of engineering systems and a more complete service.
- The Collaborative Architecture provides the means to find and select complementary partners in order to acquire skills, tacit knowledge and know-how.
- The Collaborative Architecture presents new business opportunities to manufacturing based SMEs through the provision of a source of tenders, and the active e-marketing of their processes, products and services.

- Internet-based collaboration is a significant challenge for many SMEs. With the Collaborative Toolset, time can be saved and the speed of development reduced to what is essential within industry. Manufacturing based SMEs can collaborate online, including using video conferencing, and not be faced with budgets of millions of pounds.
- The applications of the system, especially in the earlier companies' experience, resulted in many improvements being made. These are covered in detail in Submission 3B.
- The adoption rate of the Low Cost Virtual Teaming system on the Autocle@r project was 37%. Although this seems low, it was quite encouraging, given the innovative nature of the system, and bearing in mind, several companies had limited or no companies to contact.
- Over 100 students, in 20 groups, participated in the syndicate exercise on the collaborative product commerce course. All but two groups were able to solve the case study scenario within the allocated time and positive feedback was received by approximately 80% of the students. The exercise was a positive learning experience for the students as it introduced them to a new method of working and the ensuing issues.

6.7 Effects on Businesses of Not Going Ahead with the Project

During the EngD programme, a number of real examples have been identified where collaborative opportunities have been presented to SMEs. The effects on such businesses not going ahead with the project could be:

- Many SMEs will find it increasingly difficult to identify and work with suppliers, customers and partners on collaborative projects and thus struggle to expand their core competencies and offerings to their customers / OEMs.
- Unless SMEs can participate and work within new electronic mechanisms they could be deselected. For example, a 2nd Tier automotive SME was informed by their 1st Tier automotive customer that it intended to cut its supplier base from 1,300 to less than 600. Part of the selection process involved sending two of their engineers for training in Germany on how to use an online system. On arrival at their customer's premises, they were given a password and informed that any suppliers not attending and unable to work electronically via the password, would face de-selection. The day after the engineers returned, the SME was "bidding on-line to keep our own work" [20]. De-selection by automotive customers within the West Midlands is a real and immediate threat. According to a report by the West Midlands automotive partnership Accelerate, over 700 of the estimated 2,100 current West Midlands based second tier suppliers will be deselected by their automotive customers within three years [53]. The highly competitive nature of the automotive and many other industries served by manufacturing based SMEs, means that an alternative and aggressive approach is needed.
- The Collaborative Architecture offers:
    - Alternative sources of work, such as public service contracts through OJEC tenders and the health technology sector.
    - An e-business migration path for SMEs which acts as a framework for small businesses to use, in order to develop their e-business competencies enabling SMEs to up-skill.

- Provision of a SME centric collaborative system, allowing them to find potential complementary partners so they can offer more to their OEMs / customers.

6.8 Discussions

As with all aspects of the IT industry, nothing stands still for long and change itself remains the only constant. In general, Virtual Teaming and collaboration with remote customers, suppliers and partners, has recently seen unprecedented interest. This may be due to factors such as the terrorist attacks on America during September 2001 and the continued emergence of the Internet based business models and technologies. In this section points for discussion are raised.

6.8.1 E-business is About Collaboration

Recently there has been a move from solely buying and selling over the web, to greater collaborative processes. The future of e-marketplaces is to facilitate communication between buyers and sellers to work collectively on new products and processes. The main software vendors within the B2B e-marketplace sector, Commerce One, Ariba, Oracle-Peoplesoft and i2 Technologies, are strategically re-aligning their technology platforms in an attempt to create more collaboratively-focused software. This would allow individual buyers and sellers to interact in an electronic forum rather than merely exchanging order information.

Forecasts issued by the Jupiter Group, a research company, suggests that an increasing number of businesses will use e-marketplaces more for collaboration rather than merely sales over the next year [35]. This approach is supported by the Collaborative

Architecture and WMCCM – collaboration is the key to successful new business opportunities.

There are now many consolidation activities happening in the e-marketplace sector. It is predicted that there will be about 400 e-marketplaces within the next 3-5 years, implying 2-3 e-marketplaces per major industry.

6.8.2 SME Characteristics

During the course of the AutoLean III, Autocle@r and TASC Net projects, a number of generic observations were made on the behaviour of SMEs. There were times when the author was welcomed by SMEs who embraced the technologies and concepts, contributed to knowledge of the industrial environment. In contrast, there were other times (relatively rare) when great resistance to the project was displayed. A summary of the characteristics displayed by the SMEs are as follows:

- Always chasing new business opportunities. The tender feed available in Collaborative Architecture supports this requirement.
- IT is a chronic problem area in terms of human resources and technical facilities. The Collaborative Architecture presents alternative ways to progress up the e-uptake ladder.
- Limited attention span with a need to quickly show and deliver benefits and value.
- Many are secretive and suspicious, being concerned that they could lose their core competences to competitors, in a fiercely competitive industrial sector. Secure online project spaces using financial services sector level of security encryption (SSL – Secure Socket Layer) helps to address these fears.

- Opportunity driven. Continuously looking for new ways of making new business, but sometimes too busy to see it. Business opportunities feed directly from the website to SME's email inbox.
- Under continuous financial pressure. Limited cash flow means little available cash for capital investment including core business, e.g. plant and machinery. Collaborative Architecture supports this notion, through the belief that the system should be publicly funded in the same manner as other regional infrastructures and be free at point of delivery.

The nature of SMEs encountered during the research is a reflection mostly of the tough and competitive conditions of their industrial manufacturing based engineering market.

6.8.3 Regional Issues

Any country or region that cannot show the world what its companies are capable of undertaking, is unlikely to succeed in exploiting the potential of e-business. Any country or region where a search of the capability and competences cannot easily be conducted, will be at a major disadvantage. Through using competence profiling methodology, regions can provide a 'shop window' for their capability in goods and services to the world.

A key feature in the regional e-marketplace system is the ability to create viable groupings of capability. For example, consortia can be created to tackle projects which would not be possible when acting individually, and thus entering new markets within the West Midlands region.

As an example, a partnership can be created using the e-marketplace model to address the need for toilet modules for railway carriage manufacturers in the region. Toilet modules are manufactured mainly in Scandinavia, and are supplied to railway rolling stock manufacturers in the Midlands. However the core component processes, for example assembly, injection moulding, sheet metal work fabrication, and electro-hydraulic systems, are undertaken individually by many companies within the West Midlands. This work could be undertaken in the region through the establishment of consortia and collaborative tools could be then used to manage the partnership in a secure online project space.

Another example is the furniture industry in Malta, which historically has found it difficult to remain competitive with large foreign manufacturers when bidding for contracts within home and international markets. Although they have traditionally offered high quality furniture, they were too small to win contracts within the Maltese hotel industry. However, by forming collaborative clusters they were able to form commercially stronger bids, and qualify for (and win) business they could not deliver alone.

The primary membership of the regional e-marketplace are small manufacturing-based engineering businesses. The mean average of small SMEs surveyed turned over £1 million and employed approximately 25 people [26], so they were financially unattractive targets for large corporations. Individually, they find it difficult to negotiate good discounts from service and goods providers. The formation of 'clusters' of several small businesses creates a Virtual Organisation, offering an

attractive combined "market". These can provide an attractive "market" to business services providers. For example, a group of 10 SMEs on a trading estate could obtain IT services from IBM, rather than individually approaching a small supplier, of lower capability. A number of firms with a combined turnover of 10 x £1 million is a much more attractive proposition to a large company.

Existing SME e-marketplace models are structured around products, services or components, which can be described, defined and compared in catalogue type structures. The West Midlands regional model extends this to products and services that are less comparable, having "soft" features such as reputation, ethos and capability rather than "hard" features such as price, location, market sector or products.

6.9 Summary

This chapter has presented and discussed the innovative aspects of the EngD Portfolio. In particular, it has illustrated innovation in three main areas:

- The adoption of an overall Collaborative Architecture in the form of a regional e-marketplace to facilitate the move towards engineered systems and a more complete service through sourcing complementary partners. This complements the ability to identify new business opportunities in alternative industries.
- The use of a methodology to ease the introduction of collaborative working practices through the use of Virtual Teaming, geared towards use within manufacturing based SMEs.

- The development and use of a Low Cost Virtual Teaming system, aimed specifically at the requirements of manufacturing based SMEs.

SMEs have real reasons to adopt these innovations, as they face the prospect of being de-selected if they are unable to participate in e-working. With the threat of components being outsourced to low cost foreign economies, manufacturing SMEs can respond by using collaboration technology to work with the foreign competition. Rather than lose the whole business process, they would seek to retain a part (such as product design and development functions) and have overall responsibility and control, becoming the "manufacturing process expert". If they do not work in partnership with competitors and pass on a significant cost reduction to their customer, then there is a real danger of being deselected.

The Government Office of the West Midlands has responded to and endorsed the Collaborative Architecture e-business model by funding the regional e-marketplace project by £3.6 million. There have also been other significant applications of this research in areas such as training and collaborative working between SMEs. Finally, there has been considerable interest in further work by a number of industrial sectors.

In the next chapter, the conclusions from the project are drawn and further work proposed.

CHAPTER SEVEN

CONCLUSIONS AND FURTHER WORK

7 Conclusions and Further Work

The Collaborative Architecture builds on the strengths of existing e-business models and limits their weaknesses by leveraging regional resources and loyalties. It could increase sales by providing easy access to the competences and capabilities of regional SMEs for customers within their region, also nationally and internationally. The participation in collaboratively enabled work could increase skills and capability in the region's SMEs.

7.1 Conclusions

The executive summary has presented the results of the research undertaken during the research project. The focus of the research has been the development of innovation in the application of knowledge in the area of collaboration within SMEs in the automotive supply chain. In summary a number of conclusions from this work can be drawn:

- Small manufacturing based firms who are able to provide a more complete service, being able to collaborate across the supply chain through cost effective means and produce sophisticated engineered systems rather than simple component parts for their customers, can gain competitive advantage over their competitors.
- Collaborative technologies can enable closer and spontaneous working between large organisations, such as automotive OEMs, and smaller businesses in the supplier base. However, SMEs have both limited financial resources and ICT technical experience. Any collaborative system must be able to operate on the

lowest common denominator the least advanced IT software, hardware and infrastructure typically used within SMEs.

- To enable effective collaboration, the research has taken into account the IT systems, the culture and the processes through a Virtual Teaming approach. It is important to follow strict guidelines, procedures and processes in order to gain real benefits from a new way of working.
- Virtual Teams do not eliminate the need to travel. Meeting team members improves rapport, relationships, and the trust within the team, which is an important aspect of Virtual Teams. The development, implementation and testing of the Low Cost Virtual Teaming system for SMEs is unique in that it brings online electronic collaborative tools to SMEs. The implementation of a Low Cost Virtual Teaming system, using synchronous communication, led to considerable success in that 37% of those in the Autocle@r project successfully adopted the system. The use of asynchronous collaboration is more likely to succeed due to its technical nature.
- Electronic trade using collaborative e-marketplaces or hubs will dominate the future with significant revenues expected. Manufacturing based SMEs do not have the skills and resources to cope working within multi industry e-marketplace hubs, using different processes and protocols. A regional e-marketplace business model can provide a mechanism to link into e-trade and support the e-business needs of SMEs. This will also allow geographic regions to connect to the e-business highway. Without the joint negotiating power facilitated by a regional hub, local SMEs will trade at a disadvantage.
- Eventually other e-marketplaces from different regions could connect together to mutually support SMEs. This could enable complementary regions to benefit

from the sharing of knowledge, resources and skills. For example, an Automotive Injection Moulder from South Africa has been helped to form a link with a specialist-tooling provider in the West Midlands. There is little automotive support infrastructure in South Africa compared to that of the West Midlands, but competition is fierce. There are mutual benefits to be obtained by linking up both companies. Negotiation for new regional e-marketplaces is well advanced in a number of other regions.

- In the same way that a region without good transport links faces becoming an economic backwater, if the majority of regional SMEs do not / cannot participate, then the region faces becoming an e-business backwater.

There are areas where further work is needed to progress the knowledge of collaborative working within automotive SMEs presented within the executive summary.

7.2 Further Work

Following the work undertaken during the EngD, there are four areas of further work.

7.2.1 The West Midlands Collaborative Commerce Marketplace

Much of the further work from the EngD programme is now focused on the development of collaborative tools and methods for the West Midlands Collaborative Commerce Marketplace project. This is currently rolling out the Virtual Teaming methods and technology to over 500 SMEs within the West Midlands area.

This project has been funded over three years by £3.6 million from the European Regional Development Fund. SMEs are able to publicise their competencies, access

new business opportunities, identify partners for joint projects, reduce costs through aggregated purchasing and undertake electronic collaboration.

Bringing SMEs into the e-commerce arena is essential if the savings from transaction costs identified and predicted by B2B e-commerce proponents are to be actually realised. Without the SMEs onboard in e-supply chains, it is probable that B2B will get no further than what can already be provided by EDI [54]. A significant problem for manufacturing based SMEs is that existing e-business models are very product orientated, whereas the engineering industry is very process orientated. It could be argued that manufacturing based SMEs in particular do not have products as such; what they have is a design and process capability to manufacture what you require. For example, a capability for precise forming and bending wire could be utilised in many markets and many products. A company with this capability, developed in the automotive industry, has successfully applied it to the market for body-piercing jewellery. It has the largest UK market share with margins several hundred times greater than that in the automotive industry.

7.2.2 Linking of Regional e-Marketplaces

Eventually, exchanges from different regions could connect together to mutually support SMEs. This could enable complementary regions to benefit from the sharing of knowledge, resources and skills.

With the current and future drive towards sourcing goods and services from low cost labour economies, there is a desire to connect with suppliers and buyers on a global scale. With this in mind, a new regional e-marketplace for Asian suppliers and buyers

is being established in the Heathrow City area of London. The author is currently developing the "Gateway Asia" project which builds on the strengths of the Collaborative Architecture model, focuses on international collaboration and act as a outsource resource facility. Indeed this could provide an opportunity for West Midlands SMEs to access potential partners in low cost manufacturing economies, allowing them to concentrate on innovation, design and customer relationships.

7.2.3 Low Cost Virtual Teaming Integration

The Low Cost Virtual Teaming System was successfully implemented and adopted in a number of SMEs. The system comprised three main software components and consequently the installation and configuration of the system was time consuming and complex. Further development of the system into an integrated single interface is currently being undertaken in order to ease the installation process. A browser plug-in could be developed that SMEs could install on demand when visiting a centrally managed website. Visits to SMEs for the installation of the LC VT system could be eliminated, and the user presented with a single web interface controlling all the systems attributes.

7.2.4 Developing Trust Mechanisms

In future, additional functionality could be added to the collaborative e-marketplace to facilitate richer communication or added trust. By stimulating a level of trust, complementary online relationships could be brokered early in the process.

For example, eBay uses a simple system for measuring past performance of its members through a feedback system awarded by buyers or sellers. A cumulative score is calculated measuring whether the experience of the auction with the buyer or

seller was positive, neutral or negative. This creates information which is used to gauge if the buyer or seller is trustworthy or not – the higher the positive feedback the stronger the track record of delivery. A similar mechanism could be developed for the Collaborative Architecture being used to gauge whether potential collaborators, which members may know little about, are likely to deliver to expectations or not. A rating, generated by the community members, could provide this mechanism.

SMEs who can find new sources of work, form collaborative partnerships to expand their expertise, which have the tools and processes to form effective Virtual Teams, are more likely to succeed in the continuing competitive times that lie ahead.

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APPENDIX A

9 Appendix A - WMCCM Participants & Dissemination

Participants from numerous organisations, majority of which being SMEs, contributed to the development of the Collaborative Architecture, Collaborative Toolset and Collaborative Processes for the West Midlands Collaborative Commerce Marketplace. These included:

- Tom Dodd, Operations Director, Frederick Woolley Limited, Birmingham, West Midlands. SME Pressings and Assemblies Manufacturer.
- Alan Shaw, Managing Director, Regent Engineering, Birmingham West Midlands. SME Assemblies Manufacturer
- David Keene, Managing Director, RDM Ltd, Coventry, West Midlands. SME electronic systems and wiring harnesses manufacturer.
- Brian Harvey, Technical Manager, Clamonta Limited, Nuneaton, Warwickshire. SME precision engineering.
- Andrew Woolley, Partner, Woolley Solicitors Ltd, Stratford-upon Avon, Warwickshire. SME solicitor, engineering specialist.
- Malcolm Davies, Manufacturing Practice Consultant, Syntegra Ltd, Fleet, Hampshire. Large Software integrator.
- Peter Cowen, Technical Consultant, Syntegra Limited, Leeds, West Yorkshire. Large Software integrator.
- Stephen Martin, Managing Director, Bluesoft Ltd, Warwick, Warwickshire. SME Customer Relationship Management software engineering.

Dissemination of the research, in short, includes:

- Gateway Asia (www.gatewayasia.com) – use of the Collaborative Architecture to form an e-marketplace to link West London SMEs with partners in China and India etc.
- PlasTeam (www.plasteam.org – uses of the Collaborative Architecture to link together experts and 300 SMEs within the plastics and polymer process industries across 10 European member states as part of a European Union framework 6 research programme.
- West Midlands Information Technology Association (www.wmita.co.uk) – partner with WMCCM so its 250+ members can join and utilise Collaborative Architecture features and benefits. WMita also uses the WMCCM forums for private discussion area for WMita board members.
- Force Construction cluster (West Midlands based) – presentation to its members and creation of a cluster. Many members have joined of WMCCM.
- West Midlands Tooling Engineers Association – presentation to its members and creation of a cluster. Many members have joined of WMCCM.
- Institute of Metal Finishing (www.uk-finishing.org.uk) – presentation to its West Midlands members and creation of a cluster. Many members have joined of WMCCM.
- Women's Business Development Agency (www.wbda.co.uk) - presentation to its West Midlands members and creation of a cluster. Many members have joined of WMCCM.
- Health Tech (www.health-technology.org.uk) – west midlands based intuitive to support and develop health care technology, presentation to its members and creation of a cluster. Many members have joined of WMCCM.
- Bayton Road Industrial Estate (www.baytonhub.com) – North Coventry based industrial estate with over 200 companies, presentation to its members and creation of a cluster. Many members have joined of WMCCM.
- At the end of 2004, there were over 1,550 member companies and over 2,000 individual users of WMCCM.

APPENDIX B

10 Appendix B - Low Cost Virtual Teaming worksheets

Virtual Team Meeting Agenda				
Team Name:				
Meeting Purpose:				
Meeting Objective				
Meeting Outcome (desired)				
Meeting Resources:				
Date, Time, Location:				
Agenda Item (Topic)	**Outcome**	**Approach Taken**	**Duration (Minutes)**	**Who**
		TOTAL		

Record of the Meeting Profile	
Subject	**Name**

Date		Time			
Type of Meeting (Face to Face or Virtual Team)					
Rank Importance of Meeting (1 = Routine, 5 = Crisis)	1	2	3	4	5
No. topics covered					
Rank overall subject complexity (1 = Low, 5 = High)	1	2	3	4	5
Time taken (hours)					
Type of meeting 1= management 2= technical 3= administrative	1	2	3		
Rank Discussion Focus- (1 = highly focused, 5 = rambling)	1	2	3	4	5
Your Team					
Number of technical staff					
Number of admin staff					
Number of managers					
Number of directors					
How many people operated the computer?					
The Other Team					
Your Team					
Number of technical staff					
Number of admin staff					
Number of managers					
Number of directors					
How many people operated the computer?					

Meeting Method Structure						
To be completed individually and then shared with team, followed by action planning session						
1. How would you rate the balance of participation?						
Unbalanced	1	2	3	4	5	Very well balances
2. How would you rate the sharing of opinions?						
One sided	1	2	3	4	5	Equally Shared
3. How would you rate the success in resolving conflicts?						
Left unresolved	1	2	3	4	5	All resolved easily
4. What resistance or reservations were expressed?						
Which did you explore directly?						
Which did you not really explore?						
5. What reservations do you have about the approaches or methods your team is using?						
6. How did you give suggestion on how to improve team processes?						
7. How were your ideas received?						
Silence?	Questions?	Directly, in words?				
Compliance?	Attack?	Giving answers?				
8. What facial and body language did you observe?						
9. How would you rate the team's motivation to improve their approaches or methods?						
10. How would you rate your own motivations to improve your team's approaches or methods?						
11. What did you express to the team?						
12. What would you do differently next time?						
13. How clear were the team's goals and agenda for the meeting?						
No apparent goals. Confusion about goals. No agenda.	Average goal clarity. Followed most agenda items	Goals understood and accepted by all. All agenda items followed				

14. How focused was the team on the task(s) for the meeting?						
Focused on topics not relevant to the task		Most of the time spent on the task			Completely focused on the task	
15. How interested and concerned were team members?						
Bored, uninterested		Average level of interest			Involved, concerned, interested.	
16. How open were team members with one another? How freely were ideas and impressions expressed?						
Defensiveness, caution, holding back.		Some restraint			Openness in expression. Trust in others	
17. How effective was the decision-making process?						
Teams could not reach decisions		Decisions made by a few people			Decisions made by team consensus or everyone's input	
18. How successful was the meeting in achieving its objectives (rank 1-5)						
Not successful	1	2	3	4	5	Successful
19. How well did team members listen to one another?						
Many interruptions, people excluded / ignored / talked over, people not paying attention		Some interruptions, people generally attentive to others			No interruptions, frequent paraphrasing to ensure understanding, people paying attention.	
20. How well was leadership expressed and leadership needs addressed?						
Leadership not expressed; the team drifted		Only some members exhibited effective leadership			Leadership balanced among team members	
21. Degree to which VT hindered or helped communication?						
Hindered	1	2	3	4	5	Helped
22. What was the overall satisfaction with meeting?						
Not Satisfied	1	2	3	4	5	Satisfied

Technology Assessment					
How useful are the following software Applications	**Low**		**M**		**High**
Browser	1	2	3	4	5
Video	1	2	3	4	5
Audio	1	2	3	4	5
Shared whiteboard	1	2	3	4	5
CAD Tools	1	2	3	4	5
Decision support	1	2	3	4	5
Data Management System	1	2	3	4	5
Shared Applications	1	2	3	4	5
File Transfer Facility	1	2	3	4	5
Which of the following did you experience difficulties?	**None**		**M**		**Many**
Locating Menus and Controls	1	2	3	4	5
Adjusting Volume	1	2	3	4	5
Poor Audio Quality	1	2	3	4	5
Delay in Audio Transmission	1	2	3	4	5
Poor Video Quality	1	2	3	4	5
Delay in Video Transmission	1	2	3	4	5
Delay in Sending Graphics	1	2	3	4	5
Other Issues (please state)	1	2	3	4	5
How easy was it to access the different tools on the screen? (1 = very easy, 5 = very difficult)	1	2	3	4	5
How satisfied were you with the video links during the meeting (1 = very satisfied, 5 = very dissatisfied)	1	2	3	4	5
How satisfied were you with the audio links during the meeting (1 = very satisfied, 5 = very dissatisfied)	1	2	3	4	5

Meeting Structure Summary						
1. Generally speaking, our meeting was:						
Disappointing	1	2	3	4	5	Great
Disjointed	1	2	3	4	5	Crisp
Lethargic	1	2	3	4	5	Energetic
Comment:						
For our next meeting, we should:						
2. Our process:						
Was unstructured	1	2	3	4	5	Was structured
Distracted us from the task	1	2	3	4	5	Facilitated our task
Had conflict	1	2	3	4	5	Was cooperative
Comment:						
For our next meeting, we should:						
3. Brainstorm how the team can be more effective in conducting meetings. Describe specific behaviours or actions that the team should take:						
• Should continue what we already do not (e.g. fill out all parts of the agenda to prepare for our meetings)						
• Should do more of (e.g. clarify questions about agenda items in advance of the meeting when possible)						
• Should do less of (e.g. jumping to the next agenda item before getting closure on the present topic)						

APPENDIX D

12 Appendix D - Competence Profile Questionnaire

Cam Electrics Ltd (Example only)

Address:	Cam Road, West Midlands
Postcode:	CV5 7AL
Phone number	0121 1441402
Fax number:	0121 1370354
url:	http://www.cam.co.uk
Ethos:	At Cam Group we respect client confidentially and frequently enter into Non Disclosure Agreements. We encourage direct communication between our customers and our design and manufacture departments. We operate a outsource resource through the ability to act as a virtual extension to our partners and customers. Our employees play a very important part of what we do to the extent that we are currently implementing the Investors In People national quality standard. This will facilitate investment in training and development and help achieve our business goals.
Basic line of business:	Electronic Component Distributors such as industrial switches, timers and specialist motors, Precision Sheet Metalwork design and fabrication, & bespoke Electronics System Design & Assembly.
Products and services:	Electronic Component Distribution, Precision Sheet Metalwork & Electronics System Design & Assembly
Employees:	25
Turnover (£m):	1.2
Reference customers:	Link 51 Ltd (Storage Products)
Markets:	Agriculture, Automotive, Electronics, Food Beverage and Tobacco, Medical, Public Transportation
Competence transfer:	Case history for innovative products e.g. point of sale material, baked potato oven & coffee grinding machine. Developing low cost automated shelving system & electro-mechanical medical devices

Key processes:	Key Process: *Electrical or Electronic Design, Mechanical Design, Programming* Electronic and Electrical Design including PCB Design and Manufacture, Embedded Systems and Electronic Control Systems. Mainly Low Volume (Mastery: Mature, Time In Operation: 30 years) Key Process: *Assembly, Bending, Fabrication (Metal),Folding ,Mechanical Design, MIG welding, TIG welding* Precision sheet metalwork fabrication and design. Includes CNC Folding, CNC Punching (Mastery: Mature, Time In Operation: 30 years) Key Process: Technical Consultancy - including CE marking, Risk Analysis, technical testing and technical authoring (Mastery: Under Development, Time In Operation: 6 years)
Key skills:	Role: Managing Director *Electronics Design, Project Management, Sales & Marketing* Business Development, Electronics Design, Technical Authoring (CE), MIEE member (Skill Level: Expert, Years of Practice: 40 years) Role: Operations Manager *Customer Relationship Management, Electronics Design, Health and Safety, Production Management, Project Management* Operations Manager - HNC Electronics (Skill Level: Expert, Years of Practice: 30 years)

APPENDIX E

13 Appendix E - Analysis of Video Conferencing Systems

	Product	Specification	Qualify / Fail
1.	AudioVision v2.0 http://www.smithmicro.com/	Audio/video conference over the Internet, Intranet or PSTN (H.324 standard). Full-Duplex audio, colour video, whiteboard, video mail and video answering machine. ITU standard H.323 compliant.	Fail - Technical support no longer available.
2.	BuenaVista v3.1b http://www.npac.syr.edu/BuenaVista/	Multipoint videoconferencing over ISDN, LAN and the Internet. Audio, video, IRC, whiteboard, directory service (active users/conferences), Firewall / NAT support. Available for PC and SGI IRIX. Freeware	Fail – does not run on Windows 98, ME, 2000 or XP.
3.	Bull Jingle v1.0b4 (build 40) http://www.dyade.fr/jingle/	IP multicast and unicast, multipoint audio/video conferences. Full-Duplex audio, colour video, data sharing (IRC, whiteboard, file transfer, application sharing) through NM. Directory services, online web directory, phone book, interoperates with Vic/Vat/Rat. Freeware	Fail – does not run on Windows 98, ME, 2000 or XP.
4.	CamWiz for NetMeeting v3.10 http://www.labtam.com.au/	Multipoint video conferencing and still images in conjunction with NetMeeting. It allows multiple video windows (up to 6) for NetMeeting.	Fail - Technical support no longer available.
5.	Chorus Client v1.0b http://www.third.co.kr/eng/chorus.htm	Multipoint audio & video conferencing (up to 3), IRC, instant message. Chorus server, create a group, moderated groups, user search, MPEG 4 video codec	Fail – no whiteboard
6.	CineVideo/Direct v1.20 http://www.cinecom.com/	Full-Duplex audio, colour video, IRC and VOD (video on demand).	Fail – no whiteboard
7.	ClearPhone Prowin v5.2.8 http://www.clearphone.com/	Full-Duplex audio, colour video, file transfer, URL sharing, web camera, video and voice email. Online web directory, photo album, multipoint video conferencing support. Available for PC and Mac.	Fail – no whiteboard
8.	Connectix VideoPhone v3.0 http://www.connectix.com/	Audio/video conference over PSTN (H.324 standard), ISDN, LAN and the Internet. IRC, file transfer, phonebook, directory service, password protection, IP multicast broadcast.	Fail - Technical support no longer available.
9.	CUSeeMe World v1.0 http://cu-seeme.cornell.edu/	CUSeeMe is a project of Cornell University for audio and video conferencing over the Internet. Users can either connect directly to each other or they can enter a conference at a reflector. Colour video and now, view up to 24 participant windows simultaneously. Available for PC, Mac, Linux, and Amiga. Internet TV with CUSeeMe (online book), CUSeeMe v1.0 user's guide, and the CUSeeMe Network. Freeware	**Qualify for next Stage**
10.	DGWConnect v1.0.4.4 http://www.dgwconnect.com/	Multipoint video IRC (up to 6), voice, IRC, quick message (voice, video and text), video email. Pal lists, Instant snapshots to your webpage, WinAmp/ Shoutcast controls, Internet radio, file explorer and sharing.	Fail - Technical support no longer available.

11.	Dwyco video conferencing system v2.91b http://www.dwyco.com/	Full-Duplex audio, colour video, public and private IRC, file transfer, call screening. Zap message system (send and receive video/audio/IRC messages), public & private conference rooms. Directory services and multipoint video conferencing support. Freeware.	Fail – no whiteboard
12.	EasyAxess v1.30 http://english.aopen.com.tw	Audio/video conference over PSTN (H.324 standard), LAN and the Internet. EZdialer, IRC, text to speech email, video/audio mute. Directory service, video answering machine, Zoom and snapshot.	Fail – no whiteboard
13.	eye2eye v1.51c http://www.sems.co.jp/	Audio/video conference over PSTN, ISDN, LAN and the Internet. Full-Duplex audio, scalable colour video, file transfer, whiteboard, white page, dialling directory. Private groups, watch dog, call screening, video/audio privacy modes and clip/capture options.	Fail – too extensive at $499
14.	Eyeball IRC v1.1 http://www.eyeball.com/	Colour video, audio, IRC rooms, video message, file transfer, support for AIM, MSN & Yahoo messengers. Contact list, personal profile, block list, search by email and/or name. Freeware	Fail – no whiteboard
15.	Fly-Conferencing Suite v1.0 http://www.flyonthewall.tv	Colour video, audio, IRC, file transfer, white board, and multipoint video conferencing. User directory, speed dial, address book, call and session history, video record, video mail, Firewall / NAT support.	Fail – no application sharing facility
16.	Focus-Focus http://www.focusfocus.com/	Video, Audio, IRC, based around browser IRC Room. Not for business use due to high risk of spamming	Fail – no whiteboard
17.	Free WebFone v3.3 http://www.freewebfone.com/	Colour video, audio, voice and video mail, receive web broadcasting, user location service, Netscape plug-in. Available for PC, Linux, and Mac (no video yet). Freeware	Fail –no video
18.	FreeVue v1.04 http://www.freevue.com	B &W video, audio, IRC, multipoint video conferencing, online web directory, FreeVue broadcasting.	Fail – Technical support no longer available.
19.	GatherTalk v1.6 http://www.gathertalk.com/	Full-Duplex audio, colour video, IRC, whiteboard, multiparty voice conferencing, phonebook. Directory service, answering machine/voice mail, email/IP user call, Net-to-Phone ready.	Fail – Technical support no longer available.
20.	HoneyCom v4.0 http://www.honeysw.com/	Full-Duplex audio, colour video, IRC, shared image, shared whiteboard, file transfer, business card. Meeting room server, public and private meeting rooms, instant message with video snapshot (MiniMe). A gateway for LAN users, multipoint video conferencing (up to 3) support.	Fail – Technical support no longer available
21.	HoneyQ v1.6 http://www.honeysw.com/	Colour video, audio, scalable video image (320x240 & more), shared whiteboard. File transfer, frame capture, business card, URL send, instant message, HoneyQ's online list. Freeware	Fail – no application sharing facility
22.	IBM Bamba-Phone v0.21 http://www.alphaworks.ibm.com/	Full-Duplex audio, colour video, detachable remote video, numeric dial pad, speed dial, Zoom. Bandwidth speed selection buttons (LAN, 28.8, 14.4), partial compliance to the H.323 standard.	Fail – Technical support no longer available
23.	ICUII v4.84 http://www.icuii.com/	Full-Duplex audio, colour video, group and private IRC, quick message, quick message manager. Directory services, pal lists, private IRC rooms, multipoint video IRC.	Fail – no whiteboard

24.	im4cam v3.00 http://www.im.co.kr/English	Colour video, audio, IRC, whiteboard, file transfer, AV recording, send mail and send message. Directory service, search user, multipoint video conferencing (up to 10) support. Freeware	Fail – no application sharing facility
25.	Intel Video Phone v2.2 http://www.intel.com/	Full-Duplex audio, colour video, online web directory, speed dial, direct dial and H.323 proxy support. ITU standard H.323 compliant.	Fail – no whiteboard
26.	Internet CommSuite v2.0 http://www.smithmicro.com/	Colour video, audio, IRC, whiteboard, file transfer, instant message, directory service. Internet Fax, video answering machine, photo album, phone book and buddy list. ITU standard H.323 compliant.	Fail – Technical support no longer available.
27.	Internet Phone v5.01 (build 200) http://www.vocaltec.com/	Full-Duplex audio, colour video, PC-to-Phone communication, community browser. Multiparty audio conferencing, IRC, voice mail, whiteboard, file transfer, online web directory. ITU standard H.323 compliant.	Fail – Technical support no longer available
28.	InVdoIRC LE v2.5 http://www.invdochat.com/	Colour video, audio, public and private IRC, file transfer, EZ message (audio, image, and IRC), contact list. Directory services and filters, call history, snapshot, profile, IRC request dialog with picture and audio.Freeware	Fail – no whiteboard
29.	IRIS Phone v3.0 http://www.irisphone.com/index.htm	Full-Duplex audio, colour video, searchable white page, phonebook, user photo and info display. Multi user conferencing (up to 5), multiple call handling, whiteboard, file transfer. Record conversations, answering machine, audio/video mail, black list and more.	Fail – no application sharing facility
30.	Isabel v4RC http://isabel.dit.upm.es/	Video/audio/data multipoint conferencing (up to 20) over ATM, ISDN, Internet, Mbone, Satellite, Selectable events (teleconferencing), 3 modes (coordinator, client or participant). Slides, screen capture, scanner presentation, whiteboard, shared display and shared editor. Available for Sun Solaris, SGI O2, and Linux. Freeware	Fail –does not run on PC platform
31.	iSpQ Intercomm v1.1.301 http://www.ispq.com/	Colour video, audio, IRC, instant message (voice, IRC, and snapshot), and directory service. IRC groups, create a new group, invite user, multipoint video conferencing (up to 3) support.	Fail - Technical support no longer available.
32.	iSpQ VideoIRC v4.5 http://www.ispq.com/	Colour video, audio, group IRC, pal list, instant message (voice, video, and text), and directory service. Broadcast function, V-mail, multipoint video conferencing (up to 5) support. Available for PC, Mac, and MacOS X.	Fail – no whiteboard
33.	iVisit v2.563 http://www.ivisit.com/	iVisit is a video conferencing software similar to CU-SeeMe. Directory browser, bookmarks, create a room or listing, multipoint video conferencing, Firewall / NAT support. Available for PC and Mac. Freeware	**Qualify for next Stage**
34.	JoinPhone Lite v1.7 http://www.joinphone.net/English	Colour video, audio, IRC, file transfer, memo pad, calculator, address book, and audio/video recording, ITU standard H.323 v2 compliant. Freeware	Fail – no whiteboard
35.	LG VisualLINK 300 v1.0 http://www.shansys.com/	Colour video, audio, IRC, snapshot, direct call, recent call and 3 directory services. ITU standard H.323 compliant.	Fail – Technical support no longer available.

36.	LinkTEL v3.20 http://www.cyberlink.com.tw/	Audio/video conference over the Internet, Intranet, ISDN and PSTN (H.324 standard). Directory service, IRC, phone book, snapshot, Zoom, redial, Tel/IP/email call and event log.	Fail – Technical support no longer available
37.	LiveWorld v0.22 http://home.sunrise.ch/	Colour video add-on for WorldIRC. Quick IRC, private IRC, user profile, send picture, play sounds, URL and file transfer.	Fail – no whiteboard
38.	Marratech Pro v2.1 http://www.marratech.com/	Secure and private multipoint e-meetings over multicast, unicast or hybrid networks. Video, audio, IRC, whiteboard, shared application, web-based presentations, electric corridor, Firewall / NAT support. Available for PC, Sun Solaris, and Linux. Freeware	**Qualify for next Stage**
39.	MediaFone2k v1.236 http://www.netcommandtech.com/	Audio/video conference over PSTN, ISDN, LAN and the Internet. Directory service, email and IP user lookup, Zoom, application sharing through NetMeeting.	Fail - Technical support no longer available.
40.	MS Widows NetMeeting v3.01 (4.4.3396) http://www.microsoft.com/	Full-Duplex audio, colour video, IRC, whiteboard (T.126), file transfer (T.127), speed dial, directory servers. Application sharing (T.128), remote desktop sharing, host a meeting, secure call, gatekeeper/gateway calling. ITU standard H.323 compliant. Freeware	**Qualify for next Stage**
41.	PalTalk V3.2 http://www.paltalk.com/	Video call, voice call, multipoint video conferencing (up to 3), group voice conferencing, voice email, instant message. Buddy list, create a group, pal search, file transfer, Firewall / NAT support. Available for PC and Palm. Freeware	Fail – no whiteboard
42.	PhoneFree v7.2 http://www.phonefree.com/	Full-Duplex audio, colour video, IRC, file transfer, voice mail, out-going messages (OGM). Active phone book, online directory, bubble IRC groups, conference calls, multi-line calls. Call screening, DND, quick dial, caller history, web page dialling, privacy features and hot keys. Freeware	Fail – no whiteboard or shared application facility
43.	PIRCH 98 v1.0.1.1190 http://www.pirchat.com/	IRC client with video conferencing.	Fail – no whiteboard or shared application facility
44.	Reality Fusion Team View v3.0 http://www.realityfusion.com/	Video, multi channel audio, application sharing, IRC, connected to between 2 and 250 users (see only 6 maximum)	Fail – no whiteboard or shared application facility
45.	Rendez-Vous v1.0.6 http://www.gaia-interactive.com	A successor to the IVS (INRIA Videoconferencing System). An integrated audio/video/schedule tool over multicast or unicast IP. It supports multipoint video conferencing via the Mbone. Available for PC, Sun Solaris, SunOS, SGI Irix, DEC OSF1, x86 Linux and x86 FreeBSD. Freeware	Fail – no whiteboard or shared application facility
46.	SeeSaw Commun-icator v1.0 http://www.seesaw.com/	Multipoint video and voice communication (up to 6), IRC, lobbies and IRC rooms. Create, lock and password protect private rooms, moderate discussions, private pager, buddy list. Skins, portrait and profile, make buddy, mute, video capture and still photos, Firewall / NAT support.	Fail – no whiteboard

47.	SHRIMP v1.0s1 http://www-mice.cs.ucl.ac.uk/	Shrimp supports multipoint video conferencing (up to 8) via the Mbone. Shrimp tools consist of Vic (video tool), Rat (audio tool), Nte (text editor), Wbd (whiteboard) and Sdr (session directory). Available for PC, Sun Solaris and Linux. Freeware	Fail – no whiteboard
48.	SoftFone v3.0 http://softseek.zdnet.com	Full-Duplex audio, colour video, multiple calling, answering machine and voice mail.	Fail - Technical support no longer available.
49.	Syaraku v1. http://www.intercom.co.jp/english/index.html	Multi-line video conference over the Internet. IRC, file transfer, whiteboard, snapshot, watch dog, answering machine and directory service. Multimedia mail client to prepare/receive video mail, voice mail, text mail and handwritten mail	Fail – no whiteboard
50.	The vOICe v1.45 http://www.seeingwithsound.com	A vision substitute software for the blind. You can see with your ears (i.e. you can hear any visual item). HiFi stereo sound (for object on the Lt.or Rt.), built-in speech, mute, slow and fast-motion, Zoom. Freeware	Fail – no whiteboard
51.	TU-CyberFone v1.1 http://www.trulyglobal.com/	Colour video, audio, IRC, whiteboard, file transfer, speed dial, Zoom and snapshot. ITU standard H.323 compliant.	Fail - Technical support no longer available.
52.	VDOPhone v4.0b1 http://www.vdo.net/	Colour video, audio, IRC, quick note, photo album, business card, online web directory (clubVDO). Professional version supports PSTN (H.324 standard) call..	Fail - Technical support no longer available
53.	V-Fone v2.10 http://www.summersoft.com/	Full-Duplex audio, colour video, IRC, directory services, email user lookup. Bob Summers created V-Fone, ICUII, and iSpQ.	Fail - Technical support no longer available
54.	Vianet Video Interactive v2.0 http://www.vianet.com/	Colour video, audio, Wavelet video compression, bandwidth management, client-based multipoint video conferencing. T.120 support (IRC, application sharing, file transfer, whiteboard), Firewire (1394), USB, or analogue cam support. ITU standard H.323 v2 compliant.	Fail – no whiteboard
55.	VIC v2.8 http://www-nrg.ee.lbl.gov	Vic can be used either for point to point video conferencing or for multipoint conferencing via the Mbone. You need a minimum of Vat or Rat (audio tool), Wb (whiteboard) and Sd/Sdr (session directory). Available for PC, SunOS, Sun Solaris, DEC OSF/Ultrix, SGI Irix, FreeBSD, HP/PA and Linux. Freeware	Fail – No shared application facility
56.	VidCall v5.87d http://www.access.digex.net/~vidcall/vidcall1.html	Scalable video, audio (TCP/IP, Internet and PSTN), LAN multipoint conferencing (up to 10). IRC, whiteboard, phonebook, file transfer, audio/video mail, image viewing and capture.	Fail - Technical support no longer available.
57.	Video VoxPhone Gold v2.0 http://www.voxphone.com/	Full-Duplex audio, colour video, IRC, file transfer, 5 party audio conferencing, PC-to-Phone calling. Online user directory, address book, voice mail, voice fonts, caller ID, IP/email call. ITU standard H.323 compliant.	Fail – no whiteboard

58.	VideoLink Pro v2.0 http://www.smithmicro.com/	Colour video, audio, IRC, email/IP call, contact list, gatekeeper service, video studio (video mail and sentry), photo album. ITU standard H.323 v3 compliant. Available for PC and Mac.	Fail – no whiteboard
59.	VisionLink v2.0 http://www.s-vision.com/	Colour video and IRC (no audio) over PSTN, ISDN and the Internet. Address book, Zoom up/down, hot keys, speed dial, redial and video privacy.	Fail - Technical support no longer available
60.	Visitalk.com http://www.visitalk.com	Uses Netmeeting technology accessed through a web browser, hence, Full-Duplex audio, colour video, IRC, whiteboard (T.126), file transfer (T.127), speed dial, directory servers. Application sharing (T.128), remote desktop sharing, host a meeting, secure call, gatekeeper/gateway calling. ITU standard H.323 compliant. $30 per quarter	**Qualify for next Stage**
61.	Visual IRC v1.1064 http://www.hansprestige.com/	IRC with voice IRC and video conferencing. Black & White video. Freeware	Fail – no whiteboard
62.	VIZITEL ScreenShare v3.53 http://www.vizitel.com/	Interactive desktop sharing and live video over PSTN, digital cellular (GSM), ISDN, LAN and the Internet. Whiteboard, IRC, snapshot, file send, caller ID, phone book, online directory, TWAIN compatibility.	Fail – no whiteboard
63.	VocalTec Communication Client v3.0b (build 562) http://www.vocaltec.com/	Full-Duplex audio, colour video, IRC, whiteboard, file transfer, collaborative web browsing, name/IP/email call. Document sharing and remote presentation, directory service, address book, multiparty audio conferencing. ITU standard H.323 v2 compliant.	Fail - Technical support no longer available.
64.	WebPhone v4.02 http://www.webphone.com/	Full-Duplex audio, colour video, IRC, personal directory, PC-to-Phone calling. Caller ID, call conferencing, speed dial, video snapshot and online/offline voice mail. ITU standard H.323 v2 compliant.	Fail - Technical support no longer available
65.	Wintronix XtX v1.4c http://www.lamail.com/	Full-Duplex audio, colour video, IRC, whiteboard, file transfer, snapshot, address book. Directory service, audio/video recording, speed dial, video mail, multipoint video IRC (up to 10).	Fail – no expensive £100 per license.

Information collected between 1st March 2000 and 7th March 2001

APPENDIX F

14 Appendix F - Published Paper on Regional e-Marketplace

Swift, M., Bal, J., "Supporting SMEs through e-business", The Manufacturing Engineer, IEE Publications, October 2002, pp. 219-215

Supporting Manufacturing SMEs through E-Business

The West Midlands
Collaborative Commerce Marketplace

Mark Swift
Dr Jay Bal

Abstract

This article describes a three-year £3.2 million project which has been funded in the West Midlands to develop a collaborative e-commerce platform for Engineering and Manufacturing SMEs. This will allow SMEs to publicise their competencies, access new business opportunities, identify partners for joint projects, undertake electronic collaboration and reduce costs through aggregated purchasing. Dr Jay Bal, Director of the InterLean Centre and a Principal Research Fellow in the Warwick Manufacturing Group (WMG) at the University of Warwick, said:

"We are delighted that the region is supporting this innovative project to help move the region engineering SMEs from 'Fax Business to e-business' by connecting them, as a group, to the worldwide E-Commerce Highway. This funding is important in providing a platform to enable our regions SMEs to exploit e-business, to help retain business that might be transferred to other low cost parts of the world and through collaboration, extend the scope and the quality of the products manufactured in the region. The money will be spent on building an innovative platform for achieving this, and training SMEs to exploit it."

The Marketplace will provide electronic tools to raise electronic Requests for Information and Quotes (RFIs and RFQs), run electronic auctions and form collaborative project teams with other SME partners to address new opportunities.

Introduction

The emergence of the Internet and the World Wide Web (WWW) in particular has initiated further rapid change in business organisations and processes. The Internet has proven to be one of the most revolutionary economical and social phenomenon during the late 1990s. Different types of businesses have taken shape around this phenomenon and although the 'dotcom boom' may have died, it has left some lasting changes in business thinking.

The infrastructure has been built, companies are interested but the economic environment is not robust. Technology is changing from a cost of doing business to a way of doing business. Centralized e-marketplaces for B2B commerce over the Internet have created unprecedented levels of market transparency and the potential for lower procurement cost.

Bringing SMEs into the e-commerce arena is essential if the savings from transaction costs identified and predicted by B2B e-commerce proponents are to be actually realised. Without the SMEs onboard in e-supply chains, we are likely to get no further than what can already be provided by EDI[1]. The main problem for Engineering SMEs is that existing e-commerce models are very product orientated, whereas the engineering industry is very process orientated. It could be argued that engineering SMEs in particular do not have products as such, what they have is a design and process capability to make what you require. For example, a capability for forming and bending wire precisely could be utilised in many markets and many products. A company with precisely this capability, developed in the automotive industry, has successfully applied it to the market for body-piercing jewellery. They have the majority of the UK market and margins several hundred times greater than in automotive.

Defined by the UK Department of Trade and Industry e-business "describes how businesses are using information gathered electronically to improve their business processes and relationships with suppliers and consumers. This potentially covers all business areas, such as design, production, operations, customer service, as well as buying and selling"[2]. The Internet is the main facilitator of e-business. Although the definition indicates a wide scope for potential implementations, the majority of current applications focus on facilitation for businesses that produce high volume and relatively narrow, in terms of product design, variety products. Measuring e-commerce adoption in SME's, the DTI acknowledges that a company does online marketing when it has a website which publishes "marketing information, prices, and stock levels" [3]. This refers to the information usually found on electronic product catalogues.

Many engineering SME's provide highly customised products or 'one-off' jobs and thus, standard information such as prices or stock levels hardly exist. In addition, although comparisons of mass production standard products can be made electronically, based on information such as price, quality, and design, the same is not feasible in engineering business supplying 'one-off' jobs. Engineering SME's meet customer requirements based on the abilities of their jobbing processes.

The focal point of an engineering company is then the key technical engineering abilities and not the actual end products. Competence is the key term that could describe these abilities and Internet is the media that could make them available to the public with minimal costs.

Overview of the UK West Midlands Region

The UK Midlands comprises an area of 5,000 square miles with a working population of 2.45 million people. Direct employment in the automotive sector is 57,000. The County of West Midlands lies at the heart of the United Kingdom (UK) and has a population of some 5.3 million people representing 9.5% of the UKs workforce. The region is the UK's manufacturing and agricultural heartland and the hub of the national transportation network. Overall the region generates £60.9 billion in GDP for the UK economy.

For SMEs operating in the West Midlands automotive sector the figures in Table 10 provide a median descriptive profile. An SME is defined as a company having less than 250 employees.

SME Category	Mean Average
Number of employees	23
Gross turnover (x 000)	£1,000
% business with automotive sector	42%
% with largest automotive sector customer	20%
Total number of customers	55
Significant automotive sector customers	8

Table 10 –Mean average of SME's within the West Midlands

Source: AutoLean II Project Summary Report, Accelerate Partnership [4]

Based on their experience in the West Midlands region in the UK, the authors see a clear need for regional e-marketplaces to support SMEs. Furthermore, such regional marketplaces can complement the role of the multi-national industry specific E-marketplaces.

Often SMEs supply to several industries. Our research shows that for West Midlands SMEs supplying the automotive sector, on the average just under 50% of their turnover is derived from that sector. A plastic injection moulder can supply automotive, furniture and electronics industries. Does such a firm need to sign up to three vertical marketplaces, each with its own unique protocols, procedures and practices? We submit that for a 25 employee plastic injection moulder located in a large industrial region, membership in a single regional marketplace with gateway links to the industry specific e-marketplaces might be more attractive.

Whilst international marketplaces open new export opportunities, the fact is the vast majority of business done by SMEs is within their region and this will continue to be the case. The average level of exports for automotive related SMEs in the West Midlands is 3.5%. If participation in multinational marketplaces could boost this figure by a factor of 5 (a stunning achievement) this would still leave 80% within the UK and most of this would be still being within the West Midlands Region.

Whilst the international opportunities afforded by the Internet make for compelling reading, the internet can be just as useful; for conducting business in the 5,000 square mile area that is the West Midlands. Finding 'the guy just up the motorway' can be just as important as finding 'the guy on the other side of the world'.

To participate in e-commerce via the many electronic Marketplaces that exist is not viable for SMEs with limited funds and technical capability.

Estimates of the turnover in global B2B e-commerce for 2002, according to both Gartner research and Forester Research, is set to be $2,000 billon and will increase by over 160% during the following year[5]. If you look at Figure 16, which predicts the amount of trade in manufacturing, expected to flow through E-marketplaces. Given these levels and potential for new business opportunity, the number of SMEs participating in e-business activities is very low. A survey this year reported that the number of SMEs offering online e-business capability was less than 30%[6]. However companies cannot afford NOT to participate.

Within the automotive industry there are specific concerns. A report made by the University of Birmingham on the future of the automotive industry reiterates by stating that "There is little evidence that firms are seeking to reposition themselves to exploit the changes that look set to arise from developments in e-commerce. Only a minority of companies are developing, or actively planning to develop, e-commerce strategies."[7].

In the same way that region without good transport links face becoming economic backwaters. If the majority of the SMEs in a regions do-not/can-not participate then the region faces becoming an electronic backwater.

An analogy used to illustrate the effect is "It's like having a motorway running through the region, but having no junctions to access it."

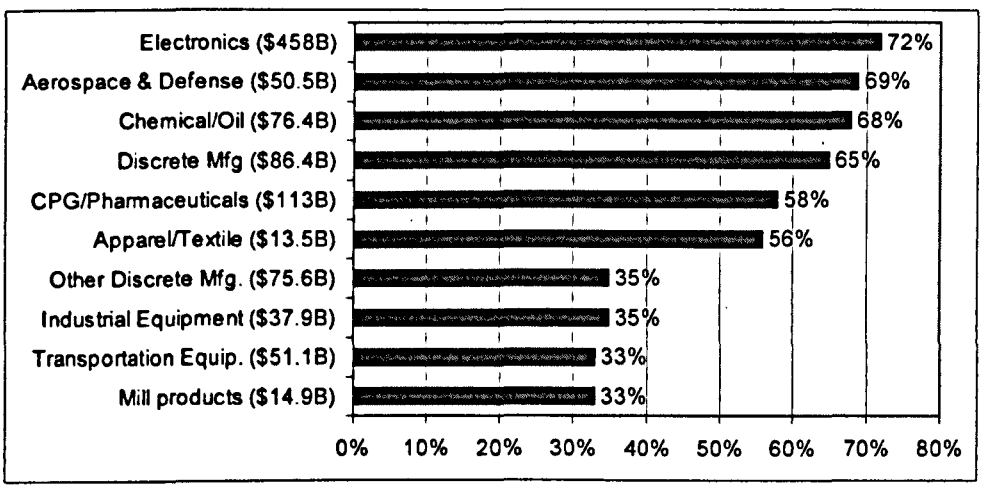

Figure 16 - Level of trade expected to flow through E-Marketplaces by 2004

Source: Philips, C. and Meeker, M., "B2B Internet Report - Collaborative Commerce", Morgan Stanley [8]

It is our view that a compelling case can be made for the regional e-marketplace approach to bring SMEs into the world of operational e- commerce. Furthermore such a regional marketplace that is rich in content and functionality will attract global interest

To date there is no accepted B2B e-marketplace model that gives investors much confidence in their long-term financial viability as independent businesses. A regional model introduces new financing options. It is also closer to the grass roots, tapping

into regional loyalties and local social dynamics that are more difficult to reach for the multinational B2B operators.

In the manufacturing supply chain, the value of engineered products exceeds that of "off the shelf" catalogue items by a significant degree. Trade in engineered products requires closer relationships of a technical nature. Thus marketplaces serving the manufacturing sector need to provide robust facilities to support on-line collaboration between supplier and customer. Such a marketplace becomes more a network of co-operative relationships operating in private behind firewalls rather than a highly competitive public e-trading post.

The positioning of the regional marketplace model in relation to the events that have and perhaps will occur is shown in the sequence of figures below.

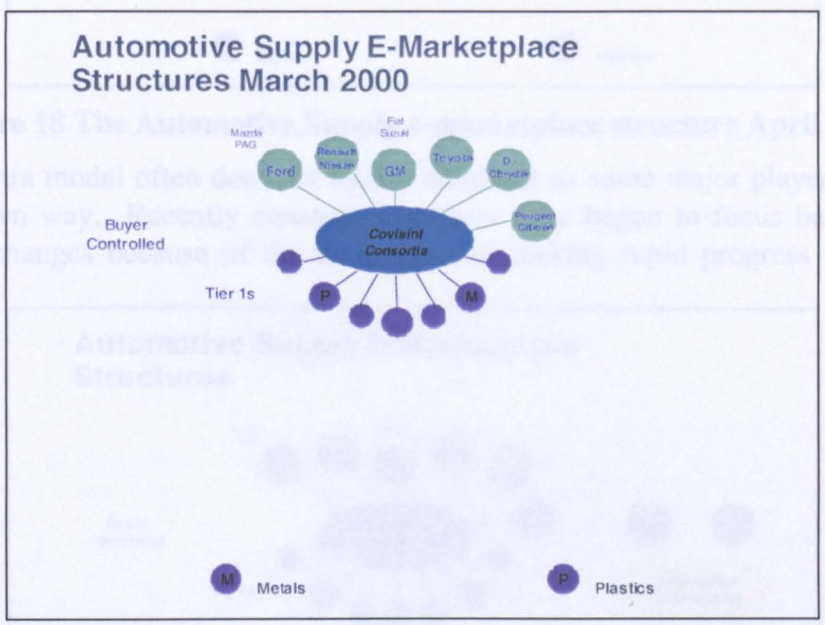

Figure 17 – The Automotive Supply e-marketplace structure March 2000

From initial efforts to establish private e-Marketplaces, the major players in most industries move to a consortia model.

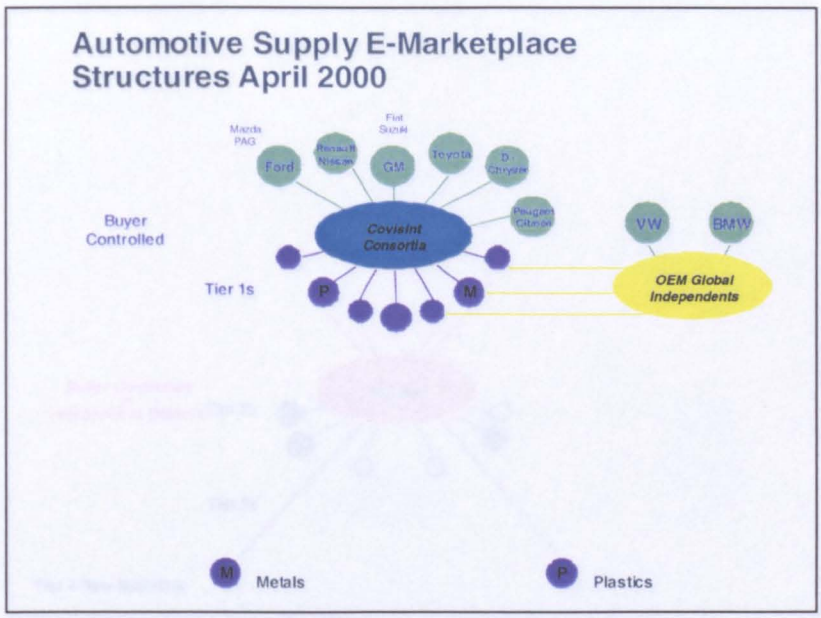

Figure 18 The Automotive Supply e-marketplace structure April 2000

The consortia model often does not totally dominate as some major players decide to go their own way. Recently consortia members have begun to focus back on their private exchanges because of the difficulties of making rapid progress whilst in a consortia.

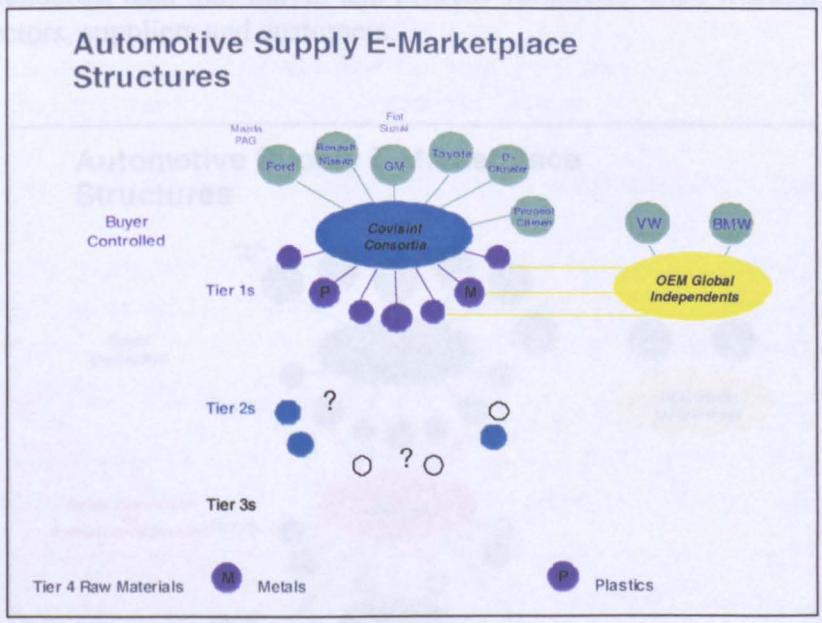

Figure 19 – SMEs within the automotive Supply e-marketplace

For the smaller tier 2, 3, 4 etc companies the problems mount as they have to work with a whole range of marketplaces. For example, a plastic moulder would buy plastic from the plastic exchange, source tooling from a tooling exchange, manufacture the products and supply to a customer via an automotive industry exchange.

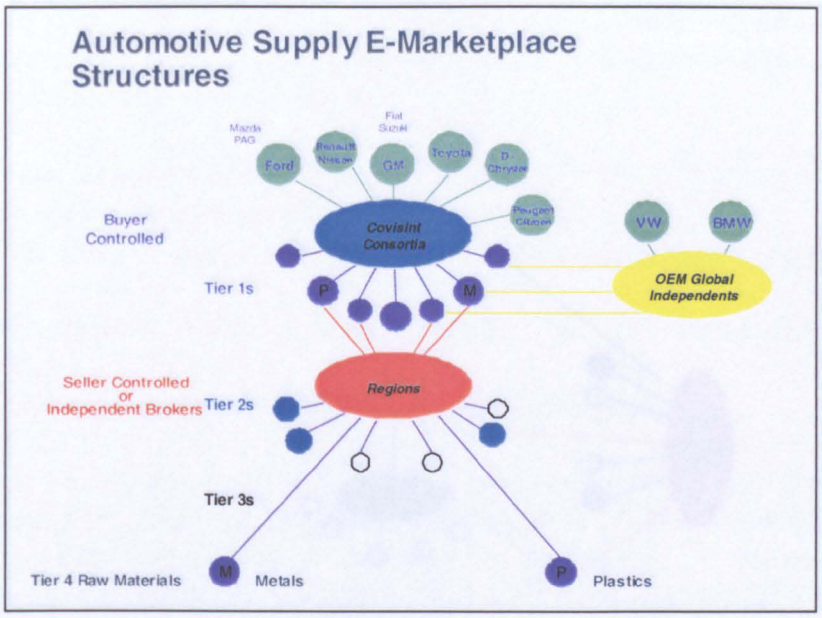

Figure 20 - Automotive Supply e-marketplace & positioning of regional marketplaces

A regional marketplace could allow the regions SMEs to connect to other exchanges and major companies in the region. The SME would not have to worry about technical standards, data translation, and process variations when working with many different sectors, suppliers and customers.

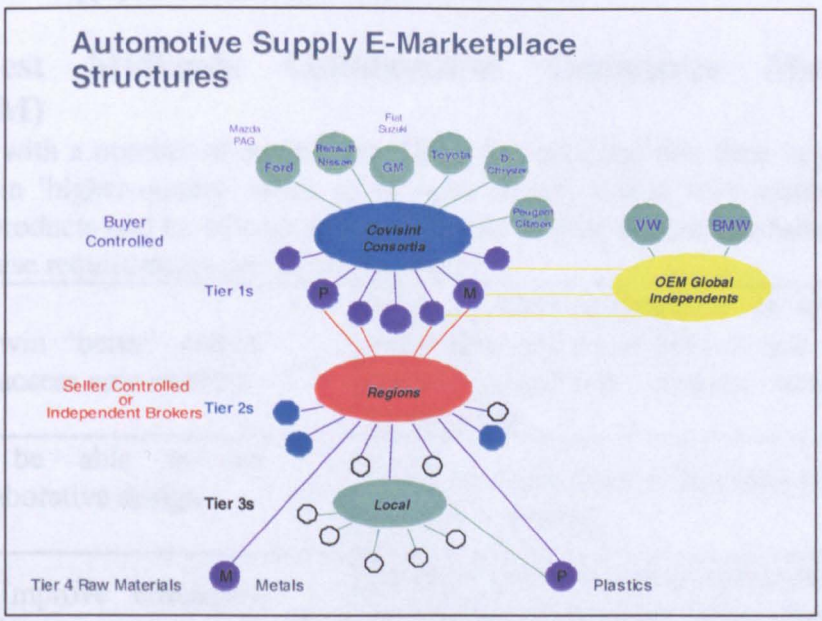

Figure 21- Automotive Supply e-marketplace and positioning of local marketplaces

The regional marketplace would support clusters, with a common look and feel and functionality, from within the region. For example a Motor Racing Industry Cluster, or a sub-regional cluster, such as a particular trading estate.

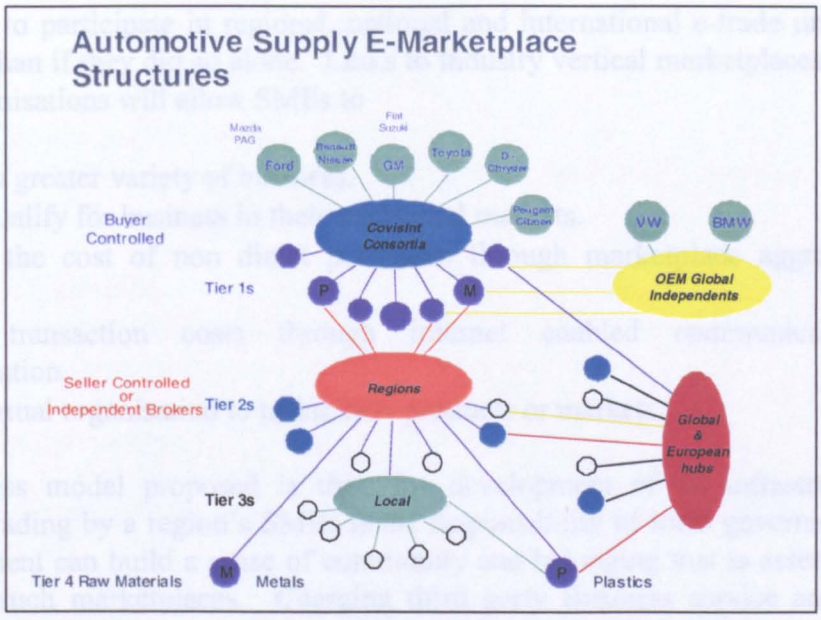

Figure 22- Automotive Supply e-marketplace & positioning of global / European hubs

Eventually we would see exchanges from different regions connecting together to mutually support SMEs. For example we have recently helped a Automotive Injection Moulder from South Africa, where there is little automotive support infrastructure, link with a specialist tooling provider in the West Midlands, where the infrastructure exists, but much reduced OEM and first tier manufacturing. Another region that this example would apply is the Monterey region of Mexico.

The West Midlands Collaborative Commerce Marketplace (WMCCM)

Interviews with a number of automotive SMEs has revealed that their key objectives are to obtain 'higher quality' work, to be more closely linked with customers in the design of products and be able to provide flexible supply without the burden of large stocks. These requirements can be interpreted as:

1. To win 'better' orders and access new markets	→	Need to show competence as well as a capability, and to be able to link up with others to provide systems rather than components.
2. To be able to do collaborative design	→	Need for collaborative Teaming capability (Virtual Teaming)
3. To improve efficiency and lower costs.	→	Need to focus on core competencies, Need to be able to leverage better terms from suppliers and partners.

Table 11 – SME Requirements of the West Midlands Automotive Sector

This project adapts the ideas and concept of E-Marketplaces to the needs of SMEs in the core West Midlands region. It will provide an electronic collaborative marketplace for the West Midlands objective 2 region for over 500 SMEs. This will

allow them to participate in regional, national and international e-trade under better conditions than if they did so alone. Links to industry vertical marketplaces and local buying organisations will allow SMEs to

- Bid for a greater variety of business,
- Better qualify for business in their traditional markets.
- Reduce the cost of non direct purchases through marketplace aggregation of volume
- Lower transaction costs through internet enabled communication and collaboration.
- Form virtual organisation to tackle new products or markets.

The Business model proposed is that, the development of an infrastructure for electronic trading by a region's SMEs is the responsibility of local government. The "local" element can build a sense of community and belonging that is essential to the success of such marketplaces. Charging third party Business service and product suppliers for access to the marketplace of over 500 SMEs can fund the running costs. The average West Midlands SME has a turnover of around £1million, so the size of the prospective marketplace is over £500million. This is an attractive target for many sellers and buyers, especially as many large blue chip organisations to not have appropriate sales channels into this type of market. Thus the E-Marketplace will only have a nominal joining fee and no transaction fees.

The key objective is to increase the sales by SMEs in the West Midlands generated by E-Commerce. A CISCO study found that 104,000 fast tracker European SMEs are effectively using online activities to increase business, reduce operating costs and interact with customers while adding value. These SMEs are seeing their margins grow from 5-20% to 20-40% over a twelve-month period. The average Automotive SME in this region has margins of around 5%-10%.

The project will achieve this sales growth by providing a B2B trading platform for the region that will:

- Lower transaction costs through electronic communication
- Provide improved access to existing and new market opportunities.
- Enhance collaboration to generate new opportunities.

It will increase sales by providing eased access to the competences and capabilities of regions SMEs for both customers within the region, nationally and internationally.

Key Functional Elements

The functionality is built around that of our existing SME regional portal www.go4gain.co.uk which has over 1100 companies already registered.

Competence Profiling and Search capability

This capability is based around understanding the processes and skills of individual Engineering SMEs (their competence) and being able to search for appropriate skills and competencies to form virtual organisations in response to enquiries. For an

example see the link to the competence profiling capability from the home page of our regional portal www.go4gain.co.uk .

Project Collaboration Capability
The system will allow companies to collaborate on engineering design projects and provide functionality to enable this collaboration.

Marketplace Capability
The ability to generate and respond to RFI's, RFQ's and to run simple auctions with associated management tools.

Purchasing Aggregation
Provide links to the catalogues of approved suppliers and service providers to the WCCM. These will allow SMEs registered on the marketplace to directly order goods and services.

Clustering Capability
Will allow companies registered on the marketplace to be clustered (i.e. have a common look and feel and set of information services) based on their location, expertise or market. For example all companies involved in the motor racing sector.

Bazaar
A section where surplus goods and requirements can be posted and traded.
External Links
Links to a number of external relevant marketplaces will be required. These will be chosen to support the requirements of companies hosted on the regional exchange.
Three links are specified – these will be to marketplaces such as Covisint, Exostar or TradeIslands.

Catalogue Capability
A limited catalogue capability will be needed for SMEs wishing to "showcase" their products, and for small suppliers wishing to make their products available.

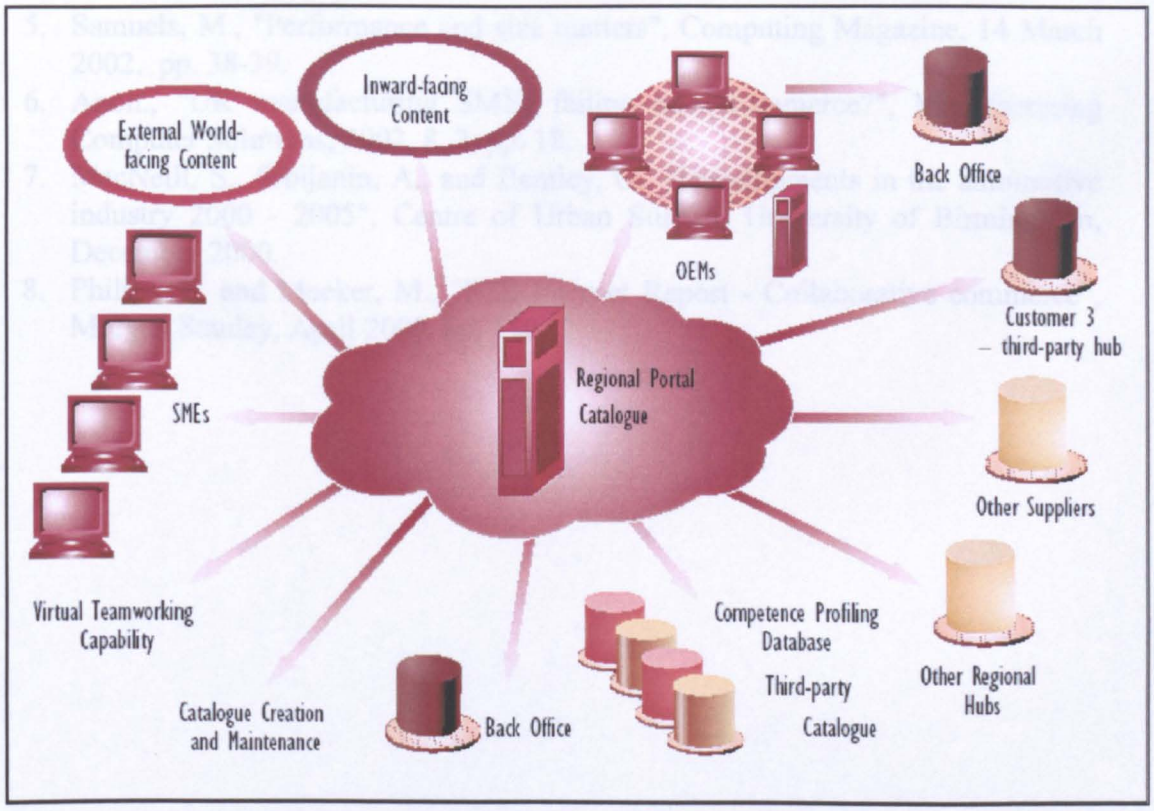

Figure 23 - An Overview of the Regional Hub Architecture.

Summary

Engineering and Manufacturing SMEs must embrace e-commerce survive and to prosper. Existing e-commerce models tend to be "product" orientated, hence the large number of catalogues that exist on the WWW. We believe that engineering companies are defined by their competencies, not by there existing products. Also existing models are biased towards the needs, resources and skills of larger companies.

The West Midlands Collaborative Commerce Marketplace builds on strengths of the existing models and limits there weaknesses by leveraging regional resources and loyalties.

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